Rocket Bikes and Boats? >>>

Japanese Zero Found in Hawaii

AIR&SPACE Smithsonian

WHY WE STILL SEARCH

NEW ATTEMPTS TO FIND AMELIA EARHART

CALLING ALL SPACE ALIENS

p. 24

Antarctic Grave: *Must Some Airmen Be Left Behind?*

JULY 2007

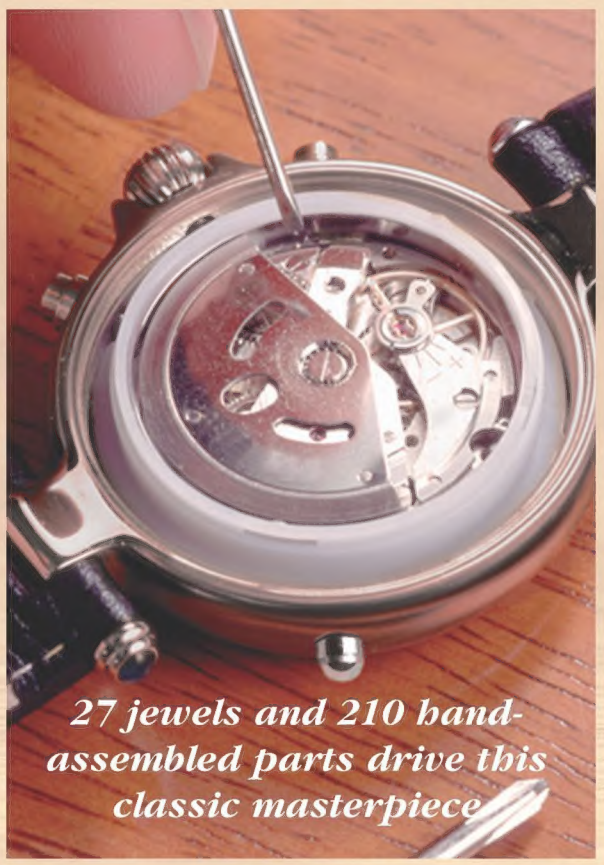
World's Most Valuable Timepiece Disappears

Back in 1933, the single most important watch ever built was engineered for a quiet millionaire collector named Henry Graves. It took over three years and the most advanced horological technique to create the multifunction masterpiece. This one-of-a-kind watch was to become the most coveted piece in the collection of the Museum of Time near Chicago. Recently this ultra-rare innovation was auctioned off for the record price of $11,030,000 by Sotheby's to a secretive anonymous collector. Now the watch is locked away in a private vault in an unknown location. We believe that a classic like this should be available to true watch aficionados, so Stauer replicated the exact Graves design in the limited edition Graves '33.

The antique enameled face and Bruguet hands are true to the original. But the real beauty of this watch is on the inside. We replicated an extremely complicated early automatic movement with 27 jewels and seven hands. There are over 210 individual parts that are assembled entirely by hand and then tested for over 15 days on Swiss calibrators to ensure accuracy. The watches are then reinspected in the United States upon their arrival.

What makes rare watches rare?

Business Week states it best…"It's the complications that can have the biggest impact on price." (*Business Week, July, 2003*). The four interior complications on our Graves™ watch display the month, day, date and the 24 hour clock graphically depicts the sun and the moon. The innovative engine for this timepiece is powered by the movement of the body as the automatic rotor winds the mainspring. It never needs batteries and never needs to be manually wound. The precision crafted gears are "lubricated" by 27 rubies that give the hands a smooth sweeping movement. And the watch is tough enough to stay water resistant to 5 atmospheres. The movement is covered by a 2-year warranty.



The face of the original 1930 s Graves timepiece from the Museum of Time.

Not only have we emulated this stunning watch of the 1930s but just as surprising, we've been able to build this luxury timepiece for a spectacular price. Many fine 27-jewel automatics that are on the market today are usually priced well over $2,000 dollars, but you can enter the rarified world of fine watch collecting for under $100. You can now wear a millionaire's watch but still keep your millions in your vest pocket. Try the handsome Graves '33 timepiece risk free for 30 days. If you are not thrilled with the quality and design, send it back for a full refund of the purchase price.

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June/July 2007 | Vol. 22, No. 2

AIR&SPACE

ON THE COVER
In her biography of Amelia Earhart, Doris Rich reports that on July 19, 1937, after a 16-day operation involving 4,000 men, 10 ships, and 65 airplanes, U.S. Navy officials declared that the search for Amelia Earhart was over. "They were wrong," Rich writes. "It had only begun."

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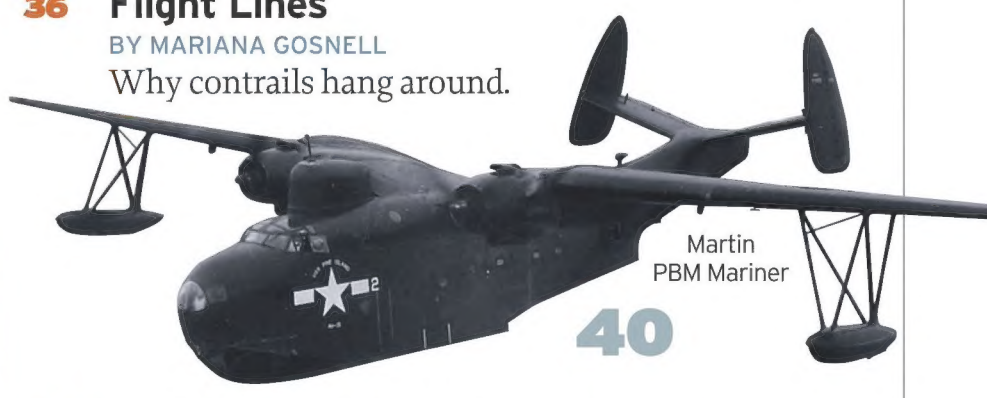

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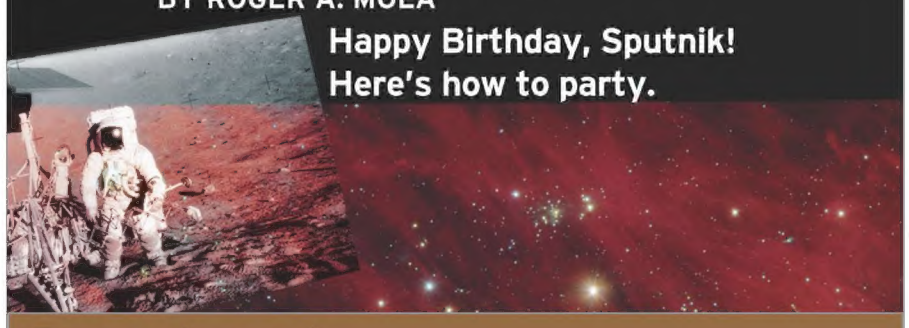

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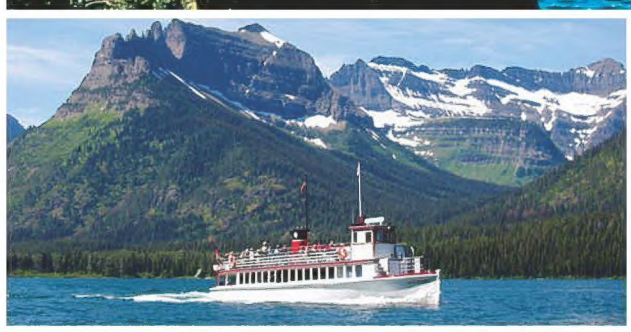

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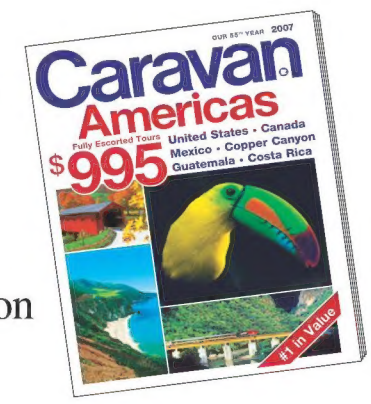

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Sheer volume is not the only issue. The Udvar-Hazy Center is the permanent repository for thousands of historic artifacts. To preserve them in good condition over the long term requires keeping the temperature at 70 (plus or minus 4) degrees Fahrenheit and the humidity at 45 (plus or minus 8) percent. That takes some powerful, high-tech doing.

Three high-pressure steam boilers heat the Center. They run on natural gas and rely for backup on a pair of 10,000-gallon oil tanks. The steam they produce also humidifies the air. Four massive chiller machines provide cold water for cooling. Supplementing this system is a thermal storage plant that produces ice overnight (to take advantage of off-peak electricity rates), which then melts to provide cooling in the heat of the day. About 20 percent of the building uses smaller, localized heating and cooling systems.

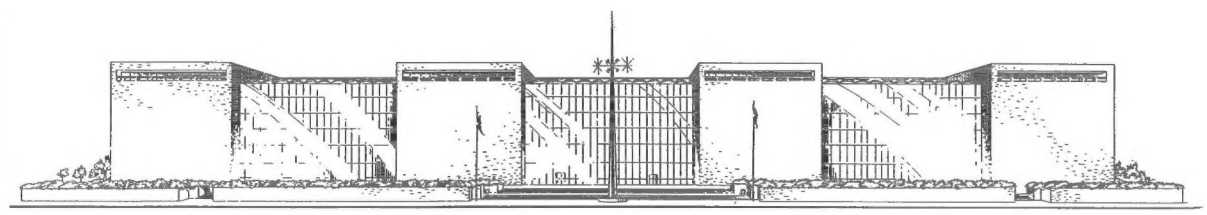
Five gigantic air-handling units located outside the building deliver this hot and cold air. Each unit filters and pumps more than half a million cubic feet of air per minute. Four units combined can replace the air in the Aviation Hangar in about 82 minutes. The filters for a single unit fill a tractor-trailer and cost $60,000. Fortunately, we don't have to change them very often.

A state-of-the-art automated digital-control system monitors and manages the heating, cooling, humidity, and carbon monoxide levels throughout the Center and keeps them within specified ranges. It helps maximize our energy efficiency, thereby lowering our substantial utility bills.

Besides controlling the environment in which our artifacts reside, we must protect them from fire. You probably have smoke detectors that alert you when you burn toast, and a fire extinguisher for more serious situations. We have a multi-faceted fire detection and alarm system, a sprinkler system that provides 100 percent coverage, a chemical extinguisher system for the McDonald's restaurant kitchen, and fire extinguishers positioned throughout the Center.

When you visit us, you'll notice how uniformly comfortable the climate is inside our hangars—not only for you, but also for the hundreds of aircraft, spacecraft, and other historic artifacts for which the Udvar-Hazy Center is home.

J.R. DAILEY IS THE DIRECTOR OF THE NATIONAL AIR AND SPACE MUSEUM.



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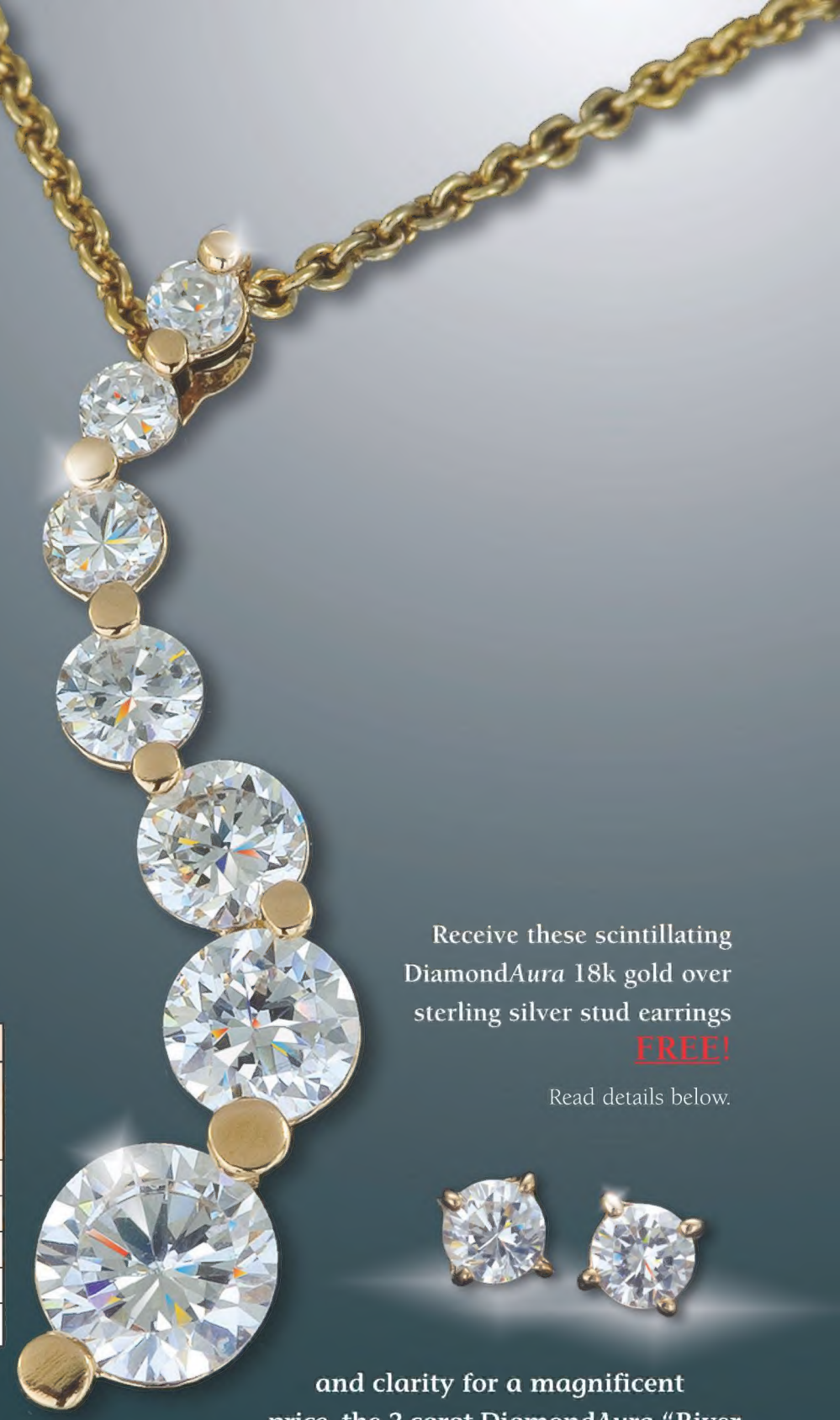

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Letters

WRITE TO US

Memoirs of a Young G-Man

"The G Machine" (Apr./May 2007) took me back to my days as a young aerodynamics engineer working on the Gemini program in the mid-1960s. We used results from testing with the Johnsville, Pennsylvania centrifuge to predict trajectories for astronauts ejecting from the Gemini capsule. The ejection seat would hit the astronauts with a large G force (over 15 Gs, if memory serves correctly) along their spines, and much testing was done to see how many Gs they could handle. We also measured how those loads changed the astronauts' centers of gravity (we referred to the change by the unflattering term "gut slop"). It was critical to know the astronauts' CGs because the rocket engine on the seat had to be pointed directly through the CG or else we could wind up with a spinning astronaut instead of an ejecting one. We had to run trajectory analysis on each individual because of differences in their weights and CGs.

For a scenario in which they needed to avoid a potential fireball, we had to get the astronauts 400 feet from the booster in 3.5 seconds, and for ejections on or near the pad, we had to be assured that they were lofted high enough to give their parachutes time to open and decelerate them to a survivable impact speed.

It was exciting stuff for a young engineer to work on, but we were all relieved that the astronauts never had to use the seats and test our analysis.

Fred Blyler
Hanover, Pennsylvania

The Unendangered Cub

"New Recipe or Classic Cub?" (Then & Now, Apr./May 2007) says the number of registered vintage Piper J-3 Cubs is 263. Our records show that the number of J-3s and their military variant, the L-4s, that are registered and flying is over 5,400.

We are proud to point out that we are a major supplier of parts to both American Legend Aircraft and Cub Crafters, producers of modern versions of this classic design, as well as a supplier of parts for vintage Cubs.

Michael D. Sellers
Univair Aircraft Corporation
Aurora, Colorado

We *Can* Stop a Nuke

It amazes me that former weapons designer Philip Coyle thinks we shouldn't build the interceptors for President Bush's proposed defense plan because he doesn't think the plan will work ("Can We Stop a Nuke?" Apr./May 2007). That's like saying that if someone threatens to punch you, you should just stand there with your hands at your side. At a minimum, trying to block punches is better than no defense at all. Over time, experience would make you better at defending yourself. No experience means no defense. Mr. Coyle's thinking is very likely one of the reasons we're not further along in the development of a system he could have confidence in.

Also, Ben Iannotta is putting words in General James Cartwright's mouth by reporting that Cartwright "sounds less convinced of the chances for a real-world success" of a missile defense system. Cartwright states that the military has at least another year to identify the bugs in the basic system and figure out how to fix them. Never does he say it's not going to work.

Dave Morris
Battle Creek, Michigan

Ben Iannotta replies: Before Cartwright talked about the bugs and the year of research needed, I asked him whether the ground-based interceptors could shoot down a North Korean missile today. He began his response by saying: "I think with good confidence that we would move in that direction." That's a far cry from claiming a good or reasonable chance. Certainly he's optimistic about the future, but the rationale for deploying the system was to provide a capability today.

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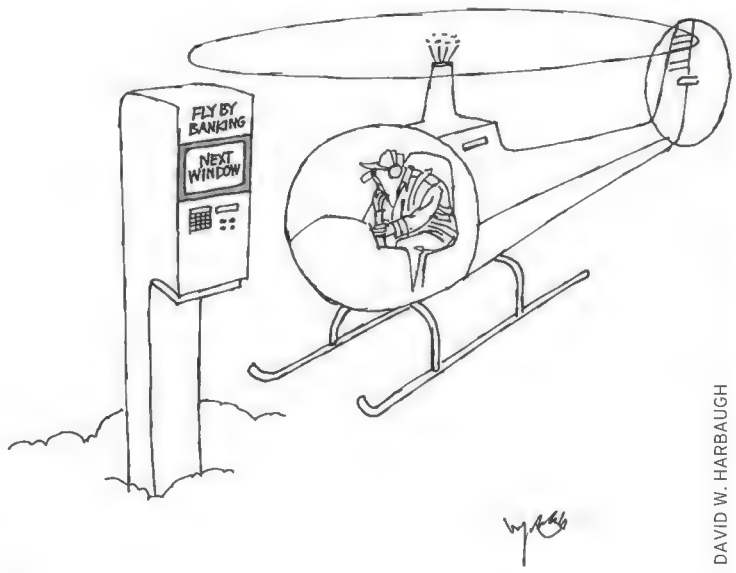

DAVID W. HARBAUGH

I was disappointed to see that the otherwise well-researched "In the Footsteps of the Mighty Eighth" (Feb./Mar. 2007) did not mention the famous Eagle Pub, located in Cambridge. It is said to be the preferred watering hole of the American flyboys from Duxford. On one drunken evening, some of the boys decided to use candles and lighters to burn their names into the pub's ceiling. The grafitti is still there, as are World War II photographs, maps, goggles, gloves, and the like.

Ashok Rajadhyaksha
Mumbai, India

Editors' reply: According to the Air Force Association, the U.S. Air Force's criteria for awarding aerial victory credits change with each war. In Vietnam, "[w]hen an F-4 downed an enemy aircraft, USAF would award two full aerial victory credits—one to the front-seater and one to the back-seater." Thus, the Air Force recognizes two Vietnam back-seaters as aces. See afa.org/magazine/valor/valoraces.asp

Can Back-Seat Guys Be Aces?

Lieutenant Colonel James T. Davenport's letter (Apr./May 2007) stating that two Air Force weapons system officers had achieved ace status in Vietnam made me take out my copy of *The American Fighter Aces Album.* On page 9 it says that the American Fighter Aces Association "does not recognize the 'guys in the back'—the observers/gunners in World War I, the radar officers in P-61s in World War II, the WSOs (weapon systems operators) in the F-4 Phantom II of Vietnam—as fighter aces.... [A] fighter ace is one who was credited for aerial victories while in control of the aircraft."

Ben C. Amsden
Fort Pierce, Florida

Corrections

Apr./May 2007 "Can We Stop a Nuke?" (1) Congressman Terry Everett represents Alabama, not Alaska. (2) The photo on pp. 22-23 shows an original Patriot, not an upgraded system.

"Airshows 2007" updates and corrections: (1) The Fayetteville, Arkansas AirFest is on September 26, not June 26. (2) The Minden-Tahoe Air Show is in Minden, not Lake Tahoe, Nevada. (3) The Gathering of Eagles in Willoughby, Ohio, is on July 13–15, not October 27 and 28. (4) In light of the Blue Angels' April 21 accident, we suggest checking the team's Web site for possible schedule changes: *www.blueangels.navy.mil/schedules.htm*

WRITE TO US at Letters, *Air & Space/Smithsonian,* MRC 513, P.O. Box 37012, Washington, DC 20013. Please type or print clearly. You must include your full address and daytime phone number.

e-mail: *editors@si.edu.* All e-mails must include your full name, mailing address, and daytime phone number.

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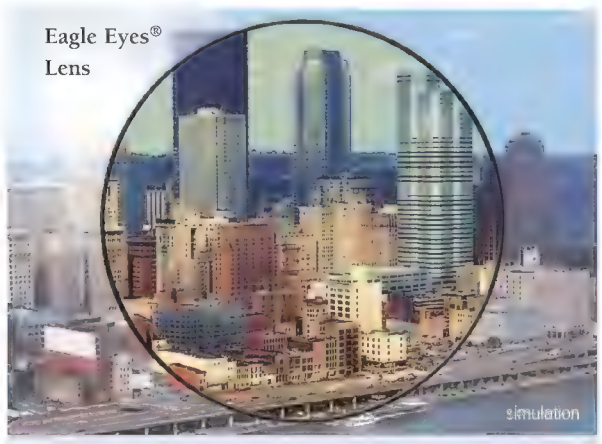

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> *—Dr. Lyda D. Tymiak*

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Using Their Heads

RICHARD NICHOLS

The Planet Head Day organizer Kevin McCartney (grinning at camera) was the only Pluto to sport a beard.

>>> **"WE ARE A VERY SMALL, RURAL MUSEUM** with essentially no budget, and have always sought projects that have a big bang for no buck," says Kevin McCartney, director of the Northern Maine Museum of Science at the University of Maine at Presque Isle. Thus was born Planet Head Day, which on February 17 celebrated the flyby of Jupiter by NASA's Pluto-bound New Horizons spacecraft. From its swing around Jupiter, New Horizons picked up a gravity boost, increasing its velocity by 9,000 mph. "More than 25 Planet Heads," McCartney reported—people who had their shaved heads (or swimcaps) painted to resemble a planet or moon—partied at the university's Gentile Hall, complete with heated swimming pool for a post-Planet Head dunk.

Planet Head Day had a dual purpose: "To celebrate life's milestones in technology, and the wonderful human ability to surmount the impossible," said Jeanie McGowan, the museum's outreach coordinator, who arranged for a university NASA IDEAS grant to provide educational outreach for New Horizons. An artist at heart, she came up with the idea of using her head, bereft of hair due to chemotherapy for cancer, as a canvas to honor the solar system and New Horizon's mission. "Expect to see Kevin orbiting around during the festivities, trying to determine if he is a true planet, a dwarf planet, or an ice ball," she predicted.

Planet Head Day is McCartney's second project-on-a-shoestring. Seven years ago, he spearheaded the creation of a 40-mile-wide model of the solar system that decorates large and lonely Aroostook County. (One Aroostook County mile equals 93 million miles, the distance from Earth to the sun.) For Pluto's 75th "birthday"—the dwarf planet was discovered in 1930—"we threw a party at the Pluto portion of the Maine Solar System Model that drew 200 kids from a wide area of northern Maine," McCartney says.

Three executives were Jupiter wannabes. Most kids clamored to be Earth or Pluto. A young lady with a halo of cardboard rings made a particularly fetching Saturn.

On Planet Head Day, four adventurous souls, including McCartney, went under barber Colin Campbell's electric clipper. The more conservative participants donned elastic swim caps (for which they made donations to a local cancer support group). University president Don Zillman was Neptune; two vice presidents each chose Jupiter, as did McGowan. Student Ryan Butler was Mars. "I got to be Pluto," McCartney says. "There were a surprising number of kids, many of whom wanted to be Earth or Pluto." Four head painters kept busy; some children helped paint their parents' heads. A young lady with a halo of cardboard rings made a particularly fetching Saturn.

"We plan to celebrate this event each year on the weekend closest to Pluto's birthday," McCartney says, "at least until New Horizons reaches Pluto in 2015 or cancer is cured. This year we used shower caps that were uncomfortable and difficult to paint. Next year we'll try theatrical 'bald wigs.' Maybe we can double the number of Planet Heads."

PATRICIA TRENNER

Mercury, Not Rising

>>> FROM THE TIME his parents let him stay home from school to watch Alan Shepard's Mercury launch from Florida's Cape Canaveral in 1961, Larry Clark has been a self-described "space nut."

Today he's an engineering manager for the space shuttle program, but even back in college he drove tour buses to the Mercury Control Center, which in the early 1960s served as the nerve center for America's human spaceflight program. To Clark's dismay, that building now sits empty and deteriorating.

To save money, NASA has targeted for possible demolition structures "that are no longer viable and not needed for future operations," agency officials say. (The control center, which supported the Mercury missions and the first manned Gemini mission in 1965, is one of only two sites on the list, along with the engineering support building at Launch Complex 34.)

According to Mario Busacca, Kennedy Space Center's historic preservation officer, "it's not habitable at this point." It would cost $3.7 million to fix the roof, replace the heating and ventilation systems, and turn the building into a tourist stop.

Some feel the repairs are worth making. "To me, the Cape side is where the real history of the space program is," Clark says.

The Brevard County Historical Commission waged a letter writing campaign to save the structure, pursuing its claim all the way to the White House, which referred it back to NASA. "Out of the money [NASA is] given, one of the things they need to do is not only launch rockets but preserve the history of previous launches," says Ed Bradford, the commission's chairman.

In 1999, the consoles and orbital map were removed for display at the Kennedy Space Center Visitor Complex. Bradford believes the original mission control should be renovated and the equipment returned. "Let the people view it at the real place, not something that's artificially contrived for the tourists," he says.

But the demand for tours at the Cape has not been high enough to justify the expense, according to Pam Steel, NASA's technical representative responsible for overseeing Kennedy's visitor operations. She notes that the tourist stop takes up only 10 percent of the building, and "you can't just fix up 10 percent of the roof."

Demolition would probably happen next year at the earliest, Busacca says, noting that the control center's listing on the National Register of Historic Places requires a lengthy decision-making process. In 2005, NASA consulted organizations from the National Park Service to the State Historic Preservation Office to the Brevard County group. If NASA decides to tear down the structure, it will talk with those organizations again and draw up an agreement to "mitigate" the loss through steps such as photographic documentation.

SUSAN FRITH

UPDATE

Herding Tomcats

LAST MARCH, FEDERAL AGENTS from U.S. Immigration and Customs Enforcement seized four Grumman F-14s from two aviation museums and from a scrap dealer who had purchased one from the producer of the TV show "JAG" ("Star Quality," Aug./Sept. 2006). The agents claim that the aircraft had not been properly demilitarized.

According to the *Los Angeles Times*, an investigation had determined that a Navy officer in charge of demilitarizing the aircraft at California's Point Mugu Naval Air Station when they were retired in 1999 improperly transferred three of them to California Public Recycling, a scrap dealer in Oxnard. The dealer sold them to Aviation Warehouse in El Mirage; AW president Mark Thomson sold the three to Yanks Air Museum in Chino. Yanks kept two; the third ended up at the neighboring Planes of Fame Museum.

A fourth, found at Southern California Aviation at Victorville Airport, had been given by the Navy to the company owned by Don Bellisario, who produced "JAG" and used the unflyable F-14 as a prop for ground shots. In 2005, Mark Thomson bought the "JAG" Tomcat and stored it at Southern California Aviation.

Federal officials dismantled the aircraft and shipped them to the Aerospace Maintenance and Regeneration Center in Tucson, Arizona, for final demilitarization and storage.

US NAVY

Something fishy? U.S. Immigration and Customs seized four decommissioned F-14s from museums and a scrap dealer.

Cosmic Tort

>>> OF ALL THE POTENTIAL hurdles to stopping a near-Earth object (NEO) from an impact that would wipe out *Homo sapiens*, governmental and legal bureaucracies often take a back seat to technical issues. But getting Earthlings to act on a menace from space will involve diplomats and attorneys as much as scientists and astronauts.

The Outer Space Treaty of 1967, which states that the fruits of space exploration be shared with all nations, obligates any nation with knowledge of a dangerous NEO to inform the rest of the world. The legal issues include who is responsible for funding a rescue, what entity can best decide whether it is necessary, when can current treaties be put aside for a last-ditch nuclear strike on an NEO, and who would be responsible for any damages resulting from a deflection or destruction mission, whether it succeeds or not.

"Are decision-makers ready for this?" asks Rusty Schweickart of the Association of Space Explorers. "No." The association of former astronauts and cosmonauts is working on a presentation to the United Nations Committee on Peaceful Uses of Outer Space that will detail mechanisms for responding to an NEO.

On the question of who should intercept an NEO, most experts have deferred to the United Nations. "No one nation should have the decision to push the button," Rene Oosterlinck, director of external relations for the European Space Agency, told attendees of a recent conference on planetary defense in Washington, D.C. But with the United Nations embroiled in debates over climate change, humanitarian aid project mismanagement, international corruption scandals, and justifications for war, it is not hard to imagine a world body divided in the face of an asteroid threat.

With at least two decades of lead time needed to make an interception viable, there would still be a large margin of error in calculating whether the object poses a

CORONADO SPEED FESTIVAL

North American AT-6 trainers show off at the Coronado Speed Festival.

UPDATE

Planes, No Trains, and Automobiles

THE SPORTS CAR CLUB OF AMERICA stopped holding races at Strategic Air Command bases in the 1950s (Oldies & Oddities, "Strategic Car Power," Apr./May 2007), but Naval Air Station North Island in San Diego, California, continues the tradition. More than 200 vintage cars will compete on the taxiways and runways of the military base on Oct. 6 and 7. Displays will include unique and exotic automobiles as well as current Navy jets and helicopters, plus vintage aircraft. As happened in the SAC car races, proceeds from the Coronado Speed Festival will benefit the military's recreation program.

A swimming pool doubles as a low-gravity simulator.

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EMBRY-RIDDLE

genuine risk when the decision to launch would have to be made. The asteroid, for example, could have a one-in-a-thousand chance of colliding with Earth.

"Unless somebody at the appropriate level is there to make decisions, we're still dinosaurs," says Schweickart, an Apollo 9 astronaut and conference speaker, referring to the ability of an asteroid strike to wipe out species.

Just trying to do anything about an object that poses a threat opens up the prospect of litigation, in the same way a person performing CPR on a heart attack victim can be sued if the victim is injured, says Frans von der Dunk of the International Institute of Air and Space Law in the Netherlands. If debris from an asteroid devastates, say, Paris, international law can hold the nations that launched the interceptor responsible for the damage. There is no limit on such damages, von der Dunk says, so "good-Samaritan protection needs to be built in" to any defense plan.

John Logsdon, director of the Space Policy Institute at George Washington University in Washington, D.C., says that many in the public call asteroid watchers "Chicken Littles" who use apocalyptic Hollywood imagery to pry money from their governments. "Maybe we sit and wait, and take the first [hit]," Logsdon says, jokingly suggesting a way to convince the public that something should be done about NEOs. Warns Von der Dunk, "The only laws these asteroids and comets listen to are those of physics."

JOE PAPPALARDO

Leonard Bruno

SCIENCE MANUSCRIPT SPECIALIST, LIBRARY OF CONGRESS

LEONARD BRUNO TOOK a temporary writing and research job in the Library of Congress' Science and Technology Division in 1969. Seven years later, he became assistant to the division chief; he joined the manuscript division in 1995.

As the science manuscript specialist, you're responsible for over 500 collections covering nearly all the major science and technology disciplines.
Covering the entire science and technology waterfront is actually enjoyable, since I'm not a scientist and therefore not an expert in any one branch. I like to think I've turned a liability into a virtue: I've become a true generalist who feels equally uncomfortable in every field. I can range, in any one day, from ecology to computers to astronomy.

Leonard Bruno treasures the Wright brothers' papers.

COURTESY LEONARD BRUNO

What are some of your prized aviation collections?
The papers of Wilbur and Orville Wright as well as the Octave Chanute Papers. Orville's 1903 diary, in which he writes an account of the brothers' first flights at Kitty Hawk, North Carolina, on December 17, 1903, is a true treasure. Wilbur's five-page letter to Octave Chanute written on May 13, 1900, is a sort of uncompromising manifesto, saying *This is what I believe and this is what I'm going to do*. And he and Orville did it! We also have a tiny brown notebook Orville kept during their months at Huffman Prairie [near Dayton, Ohio] in 1904-05, on the outside cover of which he wrote, "This book carried on machine in all of flights recorded in it. OW." We have a long letter from Benjamin Franklin to Sir Joseph Banks, president of the Royal Society of London, dated November 21, 1783 – the date of the first manned balloon flight, which he witnessed. Franklin's letter to Banks about the flight is replete with important technical descriptions and is also an insightful, witty, and prescient commentary on the achievement.

How do you decide what to acquire?
Most acquisitions come to us as a gift. We recently obtained the papers of two Nobel Prize winners – the astrophysicist Arno Penzias, whose discovery suported the Big Bang theory, and the electrical engineer Jack St. Clair Kilby, who invented the integrated circuit chip and the hand-held calculator – simply because we asked for them.

Is the general public allowed access to the collections?
Although we maintain a real research collection and function as a library rather than a museum – meaning we do not encourage tourists to walk in and ask to hold Orville's diary – we do serve any members of the general public who come to the Manuscript Division Reading Room, are of age, and are engaged in serious research. They do not have to have an institutional affiliation.

Dainty Monster

THE HEAVIEST OBJECT in the Steven F. Udvar-Hazy Center in Chantilly, Virginia, is undoubtedly the space shuttle *Enterprise*. The prize for most unwieldy, however, goes to a 700-pound, 121-foot flying wing, *Pathfinder-Plus*, a January addition to the Hazy collection.

In August 1998, the solar/electric-powered, propeller-driven wing flew at a record 80,201 feet. (The highest altitude achieved by a propeller aircraft is 96,863 feet, reached in 2001 by *Helios*, a direct descendant of *Pathfinder-Plus*.)

NASA developed *Pathfinder-Plus* with AeroVironment, a California-based manufacturer of unmanned aerial vehicles led by inventor Paul MacCready. Ever since he was a boy growing up in Connecticut, MacCready has been fascinated with flight. He started AeroVironment in 1971 as a company devoted to building environmentally friendly aircraft. "MacCready's creations are so innovative, clever, and unique," says National Air and Space Museum curator Bob van der Linden. "And they work. The *Pathfinder-Plus* is a high-lift, low-speed airfoil. The potential for that kind of aircraft is tremendous. It could perform long-term reconnaissance or function like Landsat [Earth-observing satellites]."

Opposite: It may be big, but it's fragile. *Pathfinder-Plus* was tricky to maneuver into place at the Hazy Center. Right, AeroVironment's Wyatt Sadler prepares the aircraft for hanging.

Several of MacCready's inventions are already in the Smithsonian's collection: the human-powered *Gossamer Condor* and its successor, the *Gossamer Albatross*; the solar-powered *Solar Challenger*; and the *Sunraycer* solar race car. In 1985 the Smithsonian commissioned MacCready to build a remote-controlled flying model of a pterodactyl (a flying dinosaur), which later appeared in the IMAX movie *On the Wing*.

MacCready designed *Pathfinder* in 1983 to explore high-altitude, long-duration flight. It evolved into *Pathfinder-Plus* in 1998 with the substitution of more efficient solar cells and the addition of a center wing section with a high-altitude airfoil, which added more than 22 feet to the wingspan. Developed as part of NASA's Environmental Research Aircraft and Sensor Technology project, the aircraft were technology demonstrators for flight at the low end of the speed regime. Despite having eight electric motors, *Pathfinder-Plus* didn't go anywhere quickly: Its top speed is only 25 mph.

Navigating the ungainly wing into the Hazy Center was quite a feat. But perhaps the biggest triumph of

Visitor Information

Star Party Join National Air and Space Museum staff astronomer Sean O'Brien on Saturday, June 16, in observing celestial objects in dark skies unpolluted by city lights. Sky Meadows State Park, Virginia, 8:30 p.m. to 11 p.m. Parking fee: $4 per car. Park phone no.: (540) 592-3556.

Family Day Earlier that day (June 16), take your family to Be a Pilot Family Day and Aviation Display at the Steven F. Udvar-Hazy Center in Virginia. Professional pilots will be on hand to tell tales of life in the cockpit, visitors can attend a "briefing" on flight ramp safety, and everyone can learn about the science and early history of flight. Admission is free; the event runs from 10 a.m. until 3 p.m.

Curator's Choice Occasionally a Museum curator gives a 15-minute talk about an artifact or subject of interest. At the Udvar-Hazy Center, meet at the nose of the SR-71 Blackbird aircraft at 12:30 p.m. June 7, Pieces of Apollo – Small Objects at UHC from the Space History Collection; June 21, Savior of Sikorsky: the YH-19A; July 5, Pathfinder to Mars; July 19, Police Ultralights: Low-Cost Eyes in the Skies.

DANE PENLAND (2)

logistics was in coordinating a crew from AeroVironment to arrive along with the two trailers that hauled *Pathfinder-Plus*. Reassembling the aircraft required the specialized knowledge of the AeroVironment team, says Robert Mawhinney, a museum specialist at the Paul E. Garber Preservation, Restoration and Storage Facility in Suitland, Maryland. Mawhinney has participated in most of the hanging installations at the Hazy Center, and says this one was the most complicated.

"The airplane is extremely fragile," he says. "The leading edge is built from Styrofoam about the thickness of a coffee cup. It's the kind of airplane you have to work on without touching or leaning on it."

Pathfinder-Plus was reassembled directly beneath the place in the Hazy Center where it was to be hung—once it was assembled, it couldn't be moved because it's so flexible it might bend until reaching its breaking point. Still, "the engineers said it was possible to bend the entire airplane so the tips of the wings would touch without snapping," says Mawhinney. "Hanging it was like hanging a wet noodle." As *Pathfinder-Plus* was lifted into place, it was supported on the joints of the wings and its pylons—rigid structures along the wing where the engines are attached.

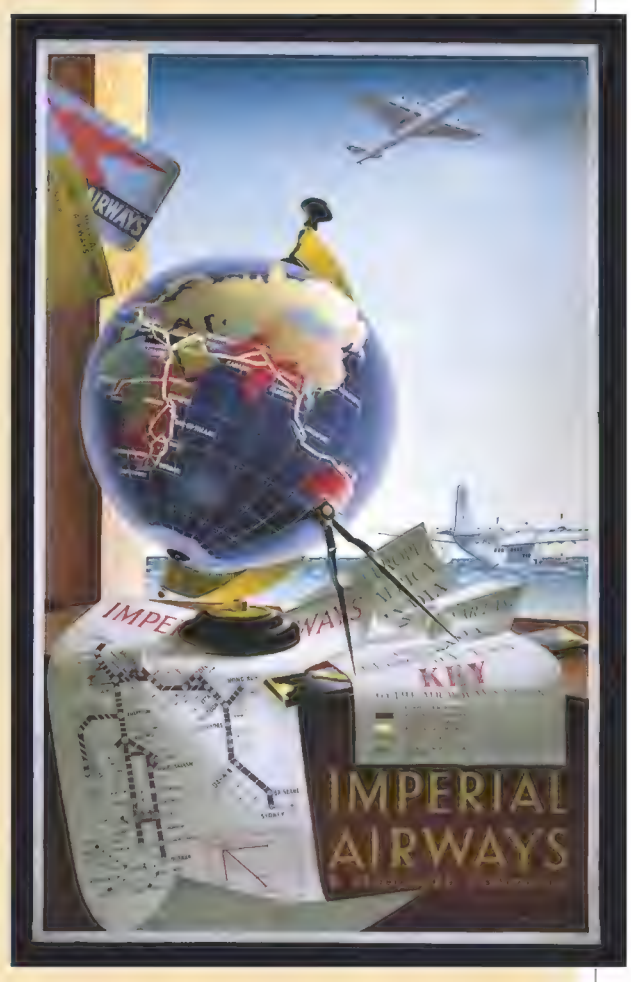
"We did the best we could as far as simulating normal flight attitude," Mawhinney says. "It's a bit more U-shaped in actual flight, but it looks fairly realistic."

BETTINA HAYMANN CHAVANNE

ARTIFACTS

"Fly Now," Then

WHEN COMMERCIAL AVIATION was still a novelty, advertisers had to figure how to attract customers. One solution: beautiful advertising posters. "The goal of the 'Fly Now!' exhibit and book is to get people thinking about a time when people didn't just get on an airplane without a second thought," says curator Joanne Gernstein London. Ads from the 1920s and '30s portrayed air travel as a luxury for the wealthy. By the Jet Age, ads were celebrating flight as something for everyone. The NASM exhibit shows, in saturated colors, how advertising has kept pace with aviation.



IMPERIAL AIRWAYS AND ASSOCIATED COMPANIES 1938

Beneath the globe in this 1938 ad is a map resembling that of the London Underground, suggesting that Imperial Airways is as easy to use as the Tube.

How to Build a Test Pilot

MUCH TO MY DELIGHT, I learned in 2005 that I would be joining class 05B at the U.S. Air Force Test Pilot School at Edwards Air Force Base in California. Class 05B—West Coast Test as we came to call ourselves—was composed of 11 engineers and navigators and 11 pilots. Many already had advanced engineering degrees. Two were foreign exchange officers from the Italian and Japanese air forces. The leader of our class of air force officers was an AV-8B Harrier pilot on exchange duty from the U.S. Marine Corps. This was true testament to the "joint" nature of today's military.

The ramp was awash in various aircraft, each unique because of its special test equipment. I've been airborne with the V-22 Osprey, F-22A Raptor, B-52 Stratofortress, 747 Airborne Laser, T-38 Talon, F-16 Fighting Falcon, NASA F-15 Eagle and F/A-18 Hornet, and F-4 Phantom II—all in one sortie. (Edwards runs dozens of test programs any given day, so it's not unusual for an entire zoo of aircraft to be in the same airspace at the same time.)

The basic curriculum aircraft were the Northrop T-38, the Lockheed F-16, and the C-12, the military variant of the Beechcraft King Air twin-engine turboprop. The challenge of flying this varied fleet was trying to stay proficient in the egress procedures and systems for each one. We took weekly emergency procedure and general knowledge tests to stay current.

Course work was equally challenging, with classes covering performance, flying qualities, aircraft systems, and test management. A typical day began with a 5 a.m. wakeup to be in place for a 6 a.m. flight brief. It wasn't uncommon to be rocketing along at Mach 1.5 by 8:30 a.m., writing flight test reports by 1, mired in complex mathematics by 2, and sweating through an academic test at 4. Then it was off to finish planning for the next day so you could get home by 7.

The capstone event for the end of the first half of Test Pilot School was a check ride in an aircraft we'd never flown before. We were off with just a Pilot Operating Handbook and a couple of math models. Each test pilot student and his or her flight test engineer student partner had to perform a slew of calculations and plan a flight profile. The aircraft used for the check ride was an amphibious Grumman HU-16 Albatross.

Imagine taking the family RV and bolting on two 1,400-horsepower radial engines, a wing, and a boat hull. The HU-16 sounds like a Harley-Davidson on startup and rumbles like an earthquake on takeoff. Any aircraft in which you get to hang your arm out the window while you taxi, gunning the engines with throttles attached to the ceiling, is off-the-chart cool.

Once past the Albatross check ride, the tenor of the course changed dramatically. The first half was concerned with quantitative evaluations of an aircraft, such as climb performance or flight stability. The second half consisted of qualitative evaluations of an aircraft and its systems while carrrying out its design mission. Known as the "qual eval" phase, it is, for many prospective students, the sole reason to apply. The qual eval phase is like being in a real-life Microsoft Flight Simulator, where you fly everything from vintage warbirds to modern bombers, transports, and fighters. For me, this phase began with the venerable Boeing KC-135R Stratotanker.

Where a fighter is akin to "fly by thought," a heavy aircraft like the KC-135 is all about managing inertia. It seems to take several seconds before the aircraft responds to control inputs. Even the huge turbofans seem to take forever to respond to throttle inputs. It requires deliberate control inputs with just the right amount of patience.

After this first "qual," West Coast Test faced a whole new batch of aircraft, including the F-4 Phantom, F/A-18 Hornet, T-2 Buckeye, MiG-15 and -21, T-6 Texan, UH-60, de Havilland Otter and Beaver, B-52 Stratofortress, B-1 bomber, C-5 Galaxy, C-17 Globemaster III, DC-3, Grob 103 sailplane, T-1 Jayhawk, Lear 23, and Giles 202 light aerobatic sportplane. By the end of the course, the class had racked up time in over 40 aircraft types and variants. There were three aircraft that will forever be special to me. The first I encountered on a field trip.

Officially, the point of the trip was to expose students to the ways the rest of the world does flight test and to build alliances among the world test centers. Unofficially, the field trip

ALL PHOTOS COURTESY: RANDY GORDON

Clockwise from top, opposite: a Test Pilot School F-16; field trip to the Reno National Air Races; cruising in a Goodyear blimp; joyriding in a two-seat F-16.

gives students a brief respite from schoolwork. My class was split into thirds and given three destinations to choose from: England, India, or Sweden. When I thought of Sweden, I saw a modern western European country with great architecture, cool jets built by Saab, and the Swedish Bikini Team of Old Milwaukee beer fame. The choice was pretty simple.

Originally designed as a ground attack fighter, the Saab Viggen has an afterburning turbofan engine almost as big as the one used in the Republic F-105 Thunderchief. Big, beefy landing gear make it possible to land the fighter on highways in the countryside, and thrust reversers make it possible to stop in less than half the distance a conventional fighter needs.

Then came the Warthog. To me, nothing so ugly was ever so beautiful. With its twin-tail, twin-engine, single-seat, single-mission configuration, the Fairchild A-10 is a cousin of the F-15. Like the Eagle, it is deadly at what it does and is obscenely over-designed to enhance survivability. We were given a couple hundred rounds of tank-killing 30-mm bullets to fire with the GAU-8 Gatling gun. When I pulled the trigger, all hell broke out in the cockpit. Time slowed down in *Matrix* fashion, and I could feel every round slam into the breach and explode from the barrel. The aircraft shuddered and the cockpit filled with the smell of cordite. Whatever was under the "death dot"—the gun pipper—when I pulled the trigger melted in a hail of dirt and debris. In World War II fighters, the pipper was fixed and the pilot had to calculate the adjustments to hit the target—compensating for winds, aircraft flexing, airspeed, G-loading, even Earth's rotation. Modern aiming computers now take almost all the guesswork out.

My favorite of the three was the Goodyear blimp, gentleman's flying at its finest. The Test Pilot School has an agreement with the Goodyear company, near Long Beach, California: When it can accommodate us, students are allowed a couple of hops.

Flying a blimp is like driving a submarine. Unlike a conventional airplane that generates lift from its wings, the blimp gets airborne by managing its own buoyancy. Twin piston engines on side-mounted pivots provide vectored thrust. We cruised at less than 20 mph; sometimes we'd slow to a hover, other times we'd fly backward. Pitch was controlled with a large trim wheel on the side of the pilot's chair. Left and right were controlled with rudder pedals, and pressure in the "bag" was controlled with two ceiling-mounted push/pull levers. Takeoff and landing were comical, requiring a small army of ground hands to weigh down and control the blimp.

The culmination of the course was the Test Management Program. It was the chance to apply everything we'd learned the previous year to a real-world test program. West Coast Testers helped develop a new voice recognition system for the F-35 Joint Strike Fighter, tested new real-time airborne data-link equipment, developed theories on pilot-induced aircraft oscillations, and investigated sailplane atmospheric energy extraction techniques—ways to enhance flight endurance. It drove home the responsibility about to be bestowed upon us as professional test pilots and engineers.

After endless academic evaluations, test reports, exacting check rides, busy field trips, and fumbling for the gear handle in a gazillion cockpits, we finally became the "Golden Arms" and could wear the graduate patch. We went to work primarily at Edwards and at Hurlburt and Eglin Air Force bases in Florida, developing new avionics, test-firing new weapons, putting a new aircraft, like the F-35, through its paces, or bringing a modernized version of an old aircraft, like the C-5C Galaxy or the A-10C Thunderbolt II, to the combat fleet. Because I was exposed to so many aircraft from various eras, I have a real appreciation for aircraft design and an even stronger passion for flight.

CAPT. RANDY GORDON, U.S. AIR FORCE

Paper Ace

I EARNED MY WINGS at the age of five or six, same as any other child. My trainer was simple to make and simple to fly—a seven-fold design ubiquitous to elementary school children then and now, an airplane that would hurtle across a classroom only to land its pilot in detention hall. As I grew into my early teens, I yearned for something different, for aircraft that were more akin to the fighter jets in my pre-adolescent dreams.

For design ideas, I searched through volumes of origami books and trolled bookstores for rare paper-airplane books. The living room became my Edwards Air Force Base; the dining room table, my Skunk Works.

After a few weeks of mixing and matching designs, I unveiled my creations to my younger cousins with the fanfare of a strike-fighter rollout. They were used to delicate works of art, to long, slender inclined-plane shapes that could ride the air with an almost regal imperturbability. My new airplanes were only as large as my opened hand, with much of the surface area of the paper tucked to re-create their real-life counterparts. Engine cowlings were dutifully folded, hardpoints for (paper) ordnance installed, and little bumps and blisters appeared on the otherwise clean nose and fuselage (forward-looking infrared, I would explain to Grandpa).

My pride and joy was my fleet of F-14s, replete with national insignia on their noses, twin tails sporting the skull and crossbones of the VF-84 Jolly Rogers or the stylized wolf's head of the VF-1 Wolfpack.

When they flew, I heard only the banshee's scream of afterburners drowning out the whines and complaints of my cousins. My fleet enjoyed total air superiority over the living room airspace, shooting down (colliding with, really) my cousins' slower-moving craft. They begged me to make them fighters of their own, but I haughtily refused. No one gives cutting-edge military hardware to the enemies.

My paper fighters came along when I began college at the University of California at Berkeley some years later. They were especially a hit with an Air Force ROTC girl I liked. But it had been years since my airplanes flew with any real purpose.

I had freshman chemistry at 1 Pimentel Hall, the largest science lecture hall on campus. The room had 523 tiered seats and nearly 5,000 square feet of enclosed space, so it was not uncommon for miscreants in the back rows to launch airplanes, especially as the term drew to a close. I was tempted to throw one of my fighters but never did.

A few days before the end of the term, I saw a student tear a sheet of paper from his notebook. A center crease here, symmetrical folds there—the moment I had been waiting for. I hurriedly produced a paper Tomcat from a cardboard tube in my backpack and straightened out its wings, stabilizers, and twin vertical tails.

We both sat in the back row, separated by about 40 seats. As the lecture concluded and people began exiting, my adversary launched his airplane toward the front of the hall. It was a large-winged craft built for a slow and smooth flight—missile fodder for my F-14. With a quiet *tallyho* and a mighty snap of my arm, I stood and hurled my fighter toward the bandit. Blowers lit, weapons hot, and the red, white, and blue Langley Stripes of the VF-2 Bounty Hunters glistening on its nose and tail, my Tomcat streaked toward its target. The other airplane was well on its way down to the front of the hall, but mine was an interceptor, its pilot a veteran of countless living room campaigns.

Splash one.

It occurred just short of the second row, opposite the hanging periodic table. No thundering applause followed the hushed *thwack* of the aerial kill. My only satisfaction came from the bewilderment of the glider's pilot, who scanned the room after my spectacular victory. As far as I was concerned, it took only one lecture hall kill to make a paper ace.

After that incident, my paper piloting days waned, and by graduation they were all but over. And what of my mighty F-14? The same fate as any Tomcat—mothballed, though not in a southern Arizona desert. In a cardboard box in a dusty closet. With actual mothballs.

KEVIN SAAVEDRA

DAVID BROWN

Brian Grote is a flight instructor with 20 years aviation experience. He also writes monthly columns on subjects pertaining to aviation.

FLYBY

ARTICLE WRITTEN BY: BRIAN GROTE

Dear Brian,

I've been flying for over 20 years. My usual run is a Denver departure at 9pm, fly to Billings, on to Cheyenne and then back to Denver by 5am. I fly a King Air 350. I love my career and I pride myself on doing the best job I possibly can.

Last time out, however, I was making lots of little mistakes. I was cleared for the ILS Runway 35R into Denver, but I couldn't pick up ATIS. That's when I looked at my radios and noticed I had dialed in the wrong frequency. I glanced again and dialed in the right frequency. I continued though my checklist and set my Radar Altimeter to 5500 feet. I was ready to make my descent and start my approach. After the outer marker I glanced at my DH again and noticed that I had set my Radar Altimeter, 67 feet low. Luckily, I landed safely, bouncing the wheels just a little.

After a couple more days in the sky I could tell my eyesight was beginning to deteriorate. I knew I wouldn't be able to renew my first class medical if I didn't do anything about it. I was really worried and started asking my peers if there was anything I could do. A co-worker gave me a bottle of Claroxan™ and told me it would help me maintain my depth perception. I was skeptical at first, but tried it anyway. As it turns out, the stuff works great. The problem is, I ran out and don't know where to find more. Have you heard of this Claroxan™ stuff? Is it available in the States?

Jason, 46 – Seattle, WA

Jason,

Not only do I know of Claroxan™, it just so happens I take it everyday. Being a pilot myself, I know that perfect visual acuity is an asset none of us can afford to lose. That's why every pilot should be protecting their eyesight before it's too late.

Claroxan™ contains ingredients proven beneficial for the eyes. Among these ingredients are lutein and zeaxanthin – powerful antioxidants that have been clinically proven to protect the retina and macula and, in some cases, reverse the damaging effects of macular degeneration. These antioxidants block damaging UV rays and halt damaging free radical oxidation in the back of the eyes. They have also been clinically proven to decrease the risk of cataracts.

Claroxan™ also contains bilberry, an anti-oxidant known to improve night vision. Bilberry's night vision enhancing effects were first noticed in England in the early 1940's. The RAF ordered English fighter pilots to eat bilberry jam on toast figuring it would give them an advantage during night raid missions against the German Luftwaffe fighters.

Claroxan's unique proprietary formulation is completely safe, all-natural and extremely affordable. As far as ordering it, you can call them toll-free at 866.775.3937, or go to "www.claroxan.com/AAS". I usually get mine within a week after ordering.

Hope this helps!
Brian

THE himalayan CATARACT project

The Himalayan Cataract Project strives to eradicate preventable and curable blindness in the Himalaya through high-quality ophthalmic care, education, and establishment of a sustainable eye care infrastructure.

Based in Asia, at Kathmandu in Nepal, the Project is empowering local physicians to alleviate the suffering caused by blindness through unique programs including skills-transfer education, cost-recovery, research, and the creation of a world-class network of eye care facilities.

In 2004 and 2005, 3% of PacificHealth profits were donated to HCP for development and construction of eye facilities in the Himalaya.

Visit CureBlindness.org to learn more about HCP.

CLAROXAN™ | LEADER IN VISION IMPROVEMENT

Sunlight, aging, and diet each cause damage to the retina and macula, which can lead to a decline in vision that glasses or contacts can't help. If you've experienced an increase in blurriness or difficulty seeing details at any range, then you know how valuable sharp vision can be. What you might not know is that in the past three years, a flood of new scientific research has been done on natural vision enhancement. This medical research suggests that ingredients in Claroxan™ may help maintain and even improve your vision, while at the same time giving you added protection against many ocular diseases

Claroxan™ may improve macular pigment density, which research shows has amazing effects on vision. By improving macular pigment density, ingredients in Claroxan™ may improve normal visual acuity, contrast sensitivity, and even glare reduction. Participants in one clinical study reported that ingredients in Claroxan™ improved their long range vision outdoors – in some cases, they were able to distinguish far away ridges up to 27 miles further than normal! Even if you have perfect vision now, Claroxan™ may help give you an edge by improving your visual reflexes and may allow you to pick up on moving objects faster than ever before.

People who count on their vision – people like pilots, hunters, military, and even pro athletes – trust Claroxan™ as the best source available for vision enhancement and protection. Claroxan™ is safe, effective, and extremely affordable. However, people with serious health concerns should consult a doctor before use.

An AMERICAN OBSESSION

SEVENTY YEARS AGO, AMELIA EARHART, HER NAVIGATOR, AND HER AIRPLANE DISAPPEARED DURING AN AROUND-THE-WORLD FLIGHT. WHY ARE PEOPLE STILL SEARCHING FOR HER?

by Paul Hoversten

HER LAST INFLIGHT RADIO TRANSMISSION was little help to a Coast Guard ship waiting below to guide her to her destination: a speck in the Pacific. "We are on the line of position 157-337.... We are running north and south," Amelia Earhart radioed from her Lockheed Electra 10E as she and navigator Fred Noonan searched desperately for tiny Howland Island on the morning of July 2, 1937. Earhart's cryptic message came on the next-to-last leg of her attempted around-the-world flight. It continues to vex searchers—and their sponsors—who still search to solve what some consider aviation's greatest mystery.

Did she crash and sink somewhere near Howland after running out of gas on the 20-hour, 2,550-mile flight from Lae, New Guinea? Did she have enough fuel to set down on some other island along the position line? Or did she wind up somewhere else altogether? One fanciful theory has her being captured by the Japanese in the Marshall Islands and later executed as an American spy; another has her living out her days under an assumed name as a housewife in New Jersey.

Seventy years after Earhart's disappearance, the larger question may be this: Why continue to search for her?

"Because it's one of the greatest mysteries of the 20th century," says Dorothy Cochrane, curator of general aviation at the National Air and Space Museum in Washington, D.C. "She was the best-known American woman pilot in the world and she just disappeared off the face of the Earth. People were tracking her flight with great interest at the time and there was a huge search for her. All these little ideas and theories that have come out since—it's all fueled because her flight was a big deal at the time."

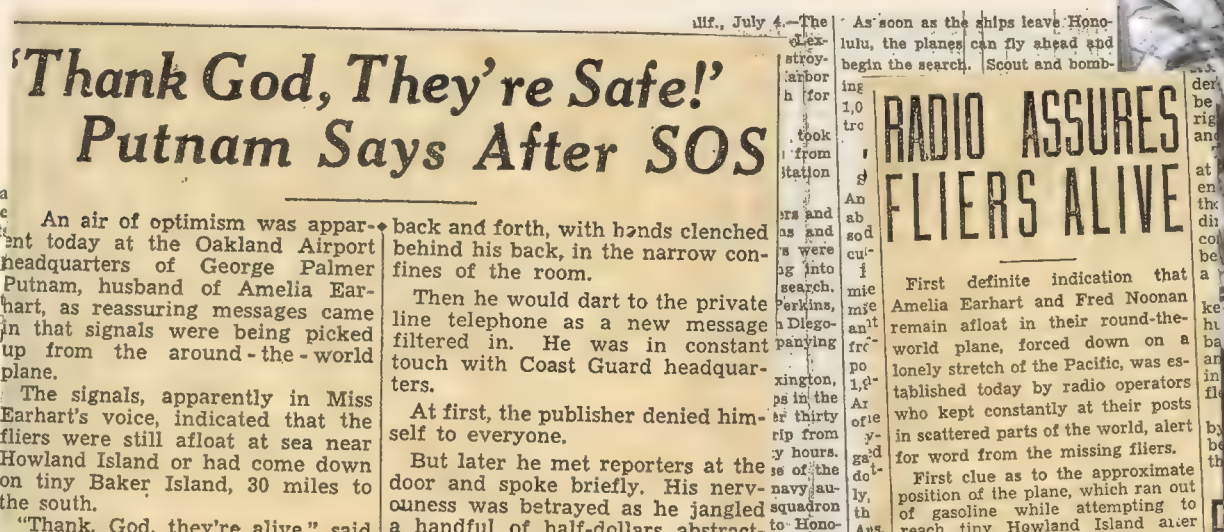
The 1920s and '30s were marked by an aeronautical record-setting frenzy. While Earhart was making headlines with her solo flights (thanks in part to promoter-husband George Putnam, the New York publisher), other aviators like high-altitude pioneer Wiley Post, industrialist Howard Hughes, speed champion Roscoe Turner, and speed-hungry Jackie Cochran were grabbing some glory of their own. But only Earhart—the reserved tomboy from Kansas who disappeared three weeks shy of her 40th birthday—still grips the public imagination.

Cochrane subscribes to the crashed-and-sank theory and she doubts the Electra will ever be found. "People want a final ending, but I don't think we're going to get it," she says. "It will always be one of those mysteries. If you find it, it's all over. I think it's fun to speculate."

Ric Gillespie, a former aviation accident insurance investigator and head of The International Group for Historic Aircraft Recovery in Wilmington, Delaware, has raised and spent more than $2 million over 18 years looking for Earhart. He's led seven expeditions to remote Gardner Island (now called Nikumaroro), south of Howland, where he believes Earhart landed on the reef-flat. His team has found, among other things, what

BELOW: NASM (SI NEG. #71-1052); OPPOSITE TOP: NASM (SI NEG. #80-11040)

Prior to the around-the-world attempt, Earhart poses for photos in the Electra, showing how she tunes in the radio receiver.



'Thank God, They're Safe!' Putnam Says After SOS

An air of optimism was apparent today at the Oakland Airport headquarters of George Palmer Putnam, husband of Amelia Earhart, as reassuring messages came in that signals were being picked up from the around-the-world plane.

The signals, apparently in Miss Earhart's voice, indicated that the fliers were still afloat at sea near Howland Island or had come down on tiny Baker Island, 30 miles to the south.

"Thank God, they're alive," said

back and forth, with hands clenched behind his back, in the narrow confines of the room.

Then he would dart to the private line telephone as a new message filtered in. He was in constant touch with Coast Guard headquarters.

At first, the publisher denied himself to everyone.

But later he met reporters at the door and spoke briefly. His nervousness was betrayed as he jangled a handful of half-dollars, abstract-

As soon as the ships leave Honolulu, the planes can fly ahead and begin the search. Scout and bomb-

RADIO ASSURES FLIERS ALIVE

First definite indication that Amelia Earhart and Fred Noonan remain afloat in their round-the-world plane, forced down on a lonely stretch of the Pacific, was established today by radio operators who kept constantly at their posts in scattered parts of the world, alert for word from the missing fliers.

First clue as to the approximate position of the plane, which ran out of gasoline while attempting to

Calls From Lost Aviators Hea
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appear to be pieces of aircraft, but nothing that definitively matches the Electra. Gillespie, who has raised several hundred thousand dollars for an eighth trip to the island in July, calls the hunt for Earhart "an American obsession."

"I don't know any other way to explain something that's been the subject of at least 50 books, countless magazine and newspaper articles, and TV documentaries," he says. "It's one of those things that people can't let go of. I've heard journalists call it the last great American mystery."

The flight itself was "not historically significant," says Gillespie, noting that it was possible in 1937 to fly commercially around the world and that newspaper reporters already had done so. Earhart's goal was not to be the first woman to fly around the world, but to be the first person to circumnavigate Earth near the equator, thereby besting in distance Wiley Post's around-the-northern-hemisphere flights. But Earhart's fame—and her husband's penchant for promotion—made everything she did newsworthy.

Central to Gillespie's hypothesis are reports of distress calls

Amercan idol: Earhart first crossed the Atlantic in 1928, as a passenger. Four years later, she flew solo from Newfoundland to Ireland in a Lockheed Vega. Below, the beaming villagers of Culmore, North Ireland, pay homage to the rising star.

NEWS CLIPS: TIGHAR COLLECTION

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EE CENTS—SUNDAY TEN CENTS OAKLAND, CALIFORNIA, SATURDAY, JULY 3, 1937 20 PAGES D NO. 3

Noonan Sends SOS From Earhart Plane; Navy Fliers Aid Hunt; Searchers Hopeful

Quest for Missing Adventurers Centered at Howland Island, With Cutter Itasca as Headquarters and Radio Director

NAVY PLANE USES EARHART GAS

Sea Is Calm and Weather Fair Over Area Where Ship Fell; Tanks Will Keep it Afloat for Days, Declare Experts

HOWLAND ISLAND, Oceania, July 3.—(U.P.)—Spurred by weak distress signals, a vast search by sea and air is under way today for Amelia Earhart and her navigator, Fred Noonan, forced down in the South Seas on a pioneering flight from New Guinea to Howland.

Miss Earhart and Noonan, on an attempted round-the-world flight in a twin-motored Lockheed-Electra monoplane, are believeed to have overshot Howland and to have been

Plane Landed

Special to The New York Times.

, July 4.—The carrier Lexington took four destroyers Diego Harbor e search for

As soon as the ships leave Honolulu, the planes can fly ahead and begin the search. Scout and bombing planes have a range of about 1,000 miles and that of the big patrol boats is 3,000 miles.

SEARCHERS'

Wyomjng and Believed She

Earhart Radio Heard by Warship After Plane Is Missing Half a Day; Vessels Search for Her on Pacific

from the Amelia
at 8:55 a. m. today.
Kenneth Bartell of nearby Huntington Park said he got the signals from KHAQQ, the call letters of the famous woman flier's plane. The signals came in a man's voice, Bartell said, leading him to believe that it was the voice of Capt. Fred Noonan, navigator for Miss Earhart.

Mrs. Noonan Collapses;

At the same time Walter McMenamy, amateur radio operator

t ships in the e over thirty he trip from venty hours. ourse of the by navy au- he squadron ed to Hono-

American flying base in that part of the world.

If Miss Earhart and her navigator, Frederick J. Noonan, came down at sea and floated indefinitely, prevailing currents might carry them westward into the Hawaii-

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from the Phoenix Islands made on Earhart's radio frequency for days after she vanished. (Gardner is part of the Phoenix chain.) The Electra could have broadcast only if it were on land, not in the water. The Coast Guard and later the Navy, believing the distress calls were real, adjusted their searches, and newspapers at the time reported Earhart and Noonan were marooned on an island. "It all comes down to the credibility of the post-crash calls," Gillespie says. "Either Earhart was on land in the Phoenix Islands or there was a hoaxer in the Phoenix Islands with her radio."

Equally adamant that the calls were bogus and that Earhart and Noonan ditched in the water is David Jourdan, a former Navy submariner and ocean engineer in Cape Porpoise, Maine, who specializes in deep-sea recoveries. His company, Nauticos, has raised and spent $4.5 million on two deep-sea sonar searches around Howland in 2002 and 2006. Armed with the materials of Earhart researcher Elgen Long, which he had purchased in the late 1990s, Jourdan so far has searched about 1,200 square miles north and west of Howland. From his research, Long postulates that Earhart's airplane ran out of gas within 52 miles of the island and is sitting somewhere in a 6,000-square-mile area at a depth of 17,000 feet.

"The analysis of all the data we have—the fuel analysis, the radio calls, other things—tells me she went into the water off Howland," says Jourdan, who sold his company's deep-water equipment to Houston-based Oceaneering International in 2002 while retaining the rights to the Nauticos name. To Jourdan, "it makes perfect sense" that Earhart would continue flying on her line of position in search of Howland—as she had radioed—until the Electra simply ran out of gas and splashed into the sea. (The "line of position" is a line plotted at a right angle to the direction toward a celestial body, based on its observed elevation above the horizon at a precise time. On the morning of July 2, 1937, the course derived from an observation of the rising sun yielded a line of position of 157–337. The numbers 157 and 337 refer to points on a compass: 157 degrees southeast and 337 northwest; a line drawn through those points would intersect Howland.)

TIGHAR COLLECTION. COURTESY ALAN BOARD

Earhart and navigator Fred Noonan relax under the tail of the Electra on a June 3 stop at Caripito, Venezuela, during the around-the-world attempt. (Their unidentified visitor, in white, may be a Standard Oil Company representative.)

At 10 a.m. on July 2, 1937, Earhart's Electra rumbled off Lae, New Guinea, headed for Howland Island. It was her last takeoff. Opposite, bottom: Over the Pacific, Earhart searcher Ric Gillespie snapped clouds whose shadows resembled islands, an illusion Earhart surely encountered.

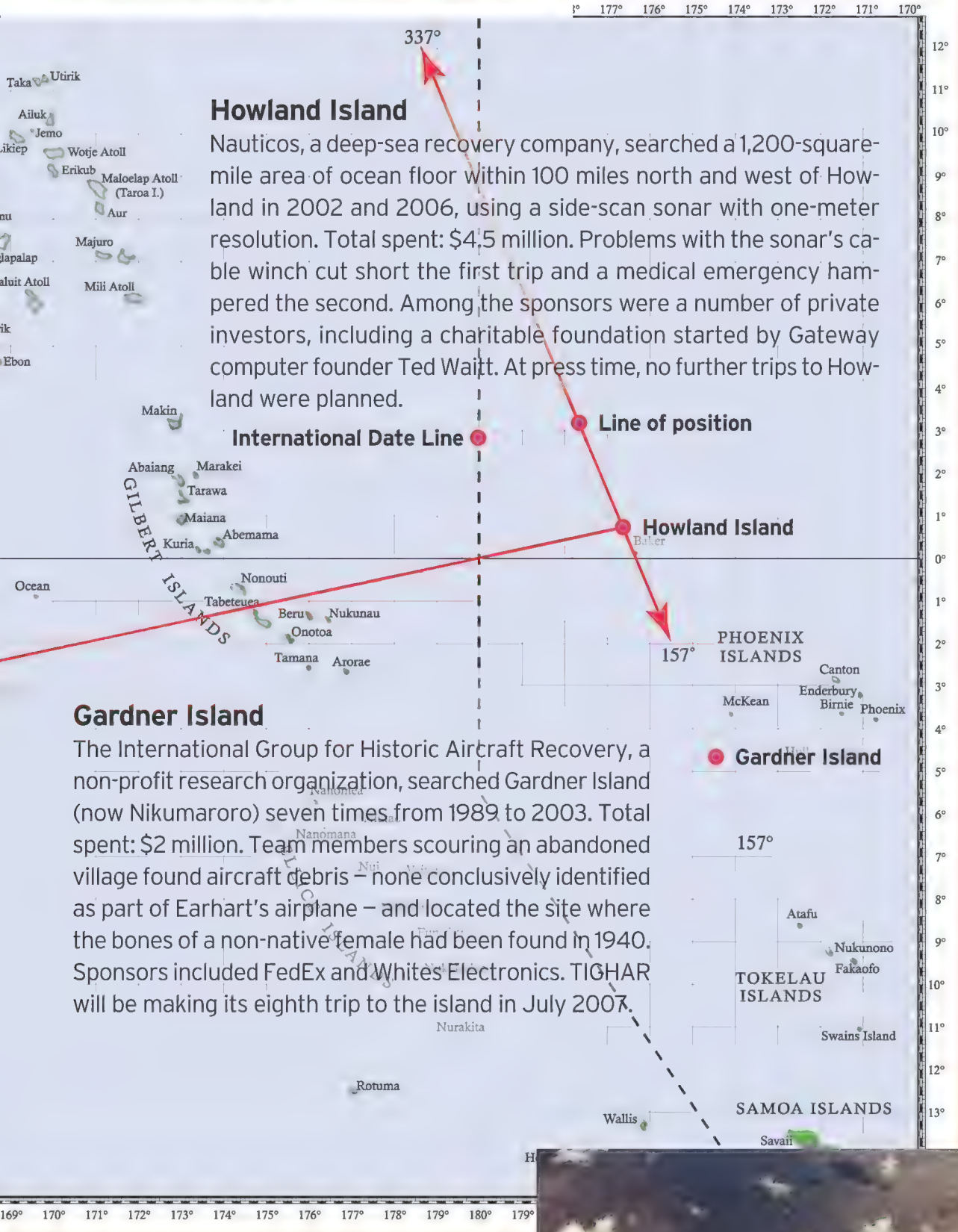
As for the airplane, "it would still be shiny," Jourdan says. "At that depth, you wouldn't even expect to find a layer of [silt]."

That's unsettling for some Earhart researchers. "The notion of seeing images of Amelia's leather jacket 18,000 feet down [disturbs] me," says Tom Crouch, senior curator of aeronautics at the National Air and Space Museum. Based on the condi-

NASM (SI NEG. #71-1059)

Gearing up for the flight to Lae, New Guinea, Earhart and Noonan load parachutes, a tail wheel, a control wheel, lubricants, and tomato juice in Port Darwin, Australia, on June 28.

TIGHAR COLLECTION



TIGHAR ARTWORK

Howland Island

Nauticos, a deep-sea recovery company, searched a 1,200-square-mile area of ocean floor within 100 miles north and west of Howland in 2002 and 2006, using a side-scan sonar with one-meter resolution. Total spent: $4.5 million. Problems with the sonar's cable winch cut short the first trip and a medical emergency hampered the second. Among the sponsors were a number of private investors, including a charitable foundation started by Gateway computer founder Ted Waitt. At press time, no further trips to Howland were planned.

Gardner Island

The International Group for Historic Aircraft Recovery, a non-profit research organization, searched Gardner Island (now Nikumaroro) seven times from 1989 to 2003. Total spent: $2 million. Team members scouring an abandoned village found aircraft debris – none conclusively identified as part of Earhart's airplane – and located the site where the bones of a non-native female had been found in 1940. Sponsors included FedEx and Whites Electronics. TIGHAR will be making its eighth trip to the island in July 2007.

tion of artifacts found aboard the *Titanic*, which came to rest in the north Atlantic at 13,000 feet, Crouch thinks that not only Earhart's jacket would have survived, but her shoes and probably her teeth as well.

"I want to know where she is, but there's something uncomfortable about finding out," Crouch says. "I'm convinced that the mystery is part of what keeps us interested. In part, we remember her because she's our favorite missing person."

Whoever finds Earhart's airplane stands to make a great deal of money. "From a business standpoint, we've always felt it was a great opportunity," Jourdan says. "There's a fantastic exhibition you could put together if we have that plane in our hands. A clever businessperson could certainly make something of this. I'm not a treasure hunter, but I'd like to do this and make some income so I could offset the cost [of looking for Earhart] and fund other expeditions."

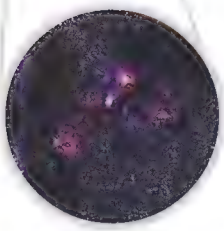
He agrees the search for Earhart may be something of an obsession. "There's some truth to that. It does grab you, but I try to keep it from being an obsession. Ric and I disagree profoundly on the basics, but he's a good guy and we get along. I encourage any of those people looking anywhere, if there's any chance you're right, let me know so I can stop wasting my time and go on and do other things."

COURTESY RIC GILLESPIE

Can We Hear Them Now?

IF EXTRATERRESTRIALS ARE TALKING, THE ALLEN TELESCOPE ARRAY IS LISTENING.

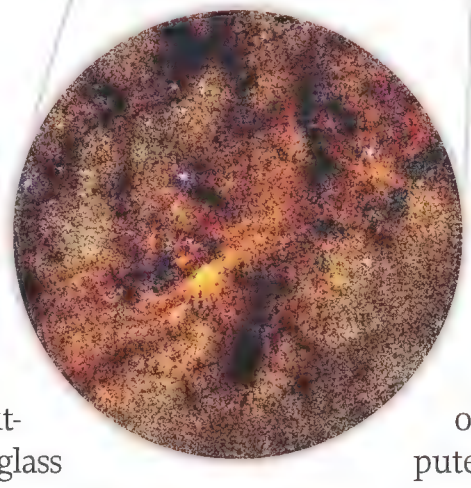
BY TONY REICHHARDT



IN THE CASCADE Mountains of northern California, within sight of Mt. Shasta's snow-topped, 14,000-foot peak, lies the high valley of Hat Creek, where they say the fishing is good. People come here in the summer for a little R&R among the tall trees, away from modern technology and its discontents. Strange, then, that the valley should also be home to one of the most futuristic projects on the planet—the Allen Telescope Array, the first radio observatory built expressly for the Search for Extra-Terrestrial Intelligence. The late physicist Philip Morrison, one of the founding fathers of SETI, called the search "the archaeology of the future," an attempt to learn whether civilizations more advanced than ours exist. Some might call that possibility unlikely. Then again, so may be the long-term survival of humanity. And we still hold hope in *that.*

On this warm day in March, Jill Tarter is sitting at a desktop computer, studying sensitivity data from telescope 2H as it pans slowly across the sky. Outside, visible through the glass doors of this modest office/utility building, are 42 identical dish telescopes, each the size of an apple tree. Only 2H is moving. The orchard's pattern appears random, with dishes facing all directions. In fact, the arrangement is as random as a computer program can make it.

Tarter writes something down, then goes into an adjoining room to pull one cable from an electronic console and plug in another. Telescope 2H is done; time to test another. If you didn't know better, you might guess this is the IT department for a satellite radio company, and that Tarter is the head geek. Look around, though, and you'll see something else is afoot. In the electronics room, one of the refrigerator-size computers sports a bumper sticker with the question, "Are We Alone?" and a Web address for the SETI Institute in Mountain View, California, where Tarter is the director for SETI research, "chief cheerleader" (her words) for the Allen Telescope Array (ATA), and the leading figure in her small and peculiar field of science (as well as a contributing edi-

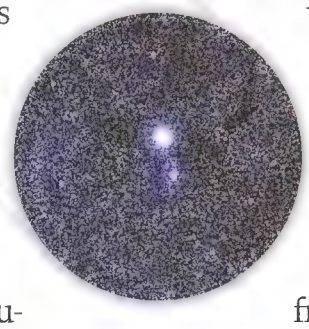


The Allen Telescope Array will scan the center of the Milky Way galaxy (above, in infrared), listening for strong signals.

OPPOSITE: ZMASS/G. KOPAN, R. HURT; LEFT: SETI INSTITUTE

Lonely sentinels, these radio telescopes in northern California's Cascade Mountains, part of a larger array, are the first dedicated to searching for signs of intelligent life in the universe.

tor of *Air & Space/Smithsonian*). Paul Horowitz of Harvard, probably the second most prominent SETI-ologist, remarked in 1988: "Jill Tarter has been plugging away at SETI for at least a decade, rebutting bad ideas, going around actually doing SETI on the world's telescopes instead of talking about it, basically calling everyone's bluff and keeping the subject from becoming too theoretical."



To "do SETI," scientists like Tarter use radio telescopes (usually) to either scan the sky or point at selected sun-like stars, listening for signals that would be recognizably artificial in origin. The rationale is that some extraterrestrial society more advanced than ours, with more powerful transmitters, might be broadcasting a signal—perhaps a series of dots and dashes, or a continuous tone—that would stand out from the natural radio emissions of stars and galaxies. Radio waves are a logical choice for interstellar communication because they cut through the gas and dust between stars. It's called the search for extraterrestrial intelligence, though it isn't really. "We look for evidence of somebody else's technology," Tarter has said. "I don't know how to find intelligence."

She is good-humored and friendly, if slightly brisk in manner, as though constantly aware she's behind in her work. She likely is: These are busy days.

Tarter has driven the five hours from her SETI Institute office in Silicon Valley to Hat Creek (the license plate of her Saab sedan reads "SETI") to spend a week running checks on the ATA telescopes. She and her husband, Jack Welch, a radio astronomer at the University of California at Berkeley and a key figure in designing this array, often make the trip in his Cessna 210 to save time. She flies too, but didn't on this trip.

Tarter worked on her first SETI project, Berkeley's SERENDIP 1, as a grad student at Hat Creek in the 1970s. She had grown up reading science fiction, and can't remember ever not believing in the possibility of extraterrestrial life. What prompted her to make it the focus of her career was a 1971 NASA study called Project Cyclops, which outlined a practical approach to building an observatory for radio SETI. Although Cyclops' array of 1,000 telescopes was deemed too expensive to build, the idea had great appeal to Tarter, and it set her on an unusual course for a scientist, where the chance of getting solid results (an alien signal!) would remain slim, but

Jill Tarter likes all the tinkering and testing, but says: "The frustrating thing is, I want it now. There are observations I want to make."

The telescope feed captures long radio waves at its base, short ones at the tip.

there would always be plenty of work to do improving detection methods. Like almost every search conducted to date, Tarter's first venture into SETI 30 years ago had to piggyback on another radio astronomy project. Now, at 63, she finally has a dedicated observatory in the Allen array, like a lifetime renter moving up to buy.

More than 100 SETI searches have been conducted since 1960, with no signal detected. That sounds conclusive, but it's not. Most searches have been very limited—a patch of sky here, a narrow slice of the radio spectrum there. It's as though a driver going cross-country had tuned to a single radio channel for a few seconds, heard nothing, tried two more channels the next day, heard nothing, and concluded that the United States has no radio stations.

With Tarter in the lead, the privately funded SETI Institute (Congress cut all NASA funding for SETI in 1993) conducted the most comprehensive search to date, called Project Phoenix, from 1995 to 2004. Phoenix targeted about 1,000 sun-like stars, spending a few minutes listening for radio signals from each. "There wasn't a transmitter pointed our way when we looked," says Tarter. "Does that mean there's no technological civilization? I don't know. That's a much harder conclusion to draw."

Phoenix took 10 years because the SETI-ologists had to borrow observing time, a week here and a month there, on other people's radio telescopes, including the 1,000-foot-diameter Arecibo dish in Puerto Rico and the 210-foot dish at Parkes, Australia. Tarter's new array of telescopes will do SETI operations all day, every day. It will also be used by scientists for conventional radio astronomy—Berkeley is partnered with the SETI Institute on the project—but this time, they're the ones who will be along for the ride.

Phoenix listened for signals over a range of three gigahertz—a wide swath of radio spectrum by SETI standards. The ATA will monitor 10 gigahertz continuously, targeting 1 million stars with enough sensitivity to detect an Arecibo-size transmitter broadcasting from 1,000 light-years away. That is, if the array grows from the current 42 to the planned 350 telescopes. Any radio telescope's sensitivity to faint signals depends on its total collecting area, whether it's a giant single dish like Arecibo or lots of little ones. The ATA philosophy is to build many small dishes as cheaply as possible, then rely on sophisticated software to process the signals.

Economy is a necessity for the project, which has only seven people working at the Hat Creek site. They buy off-the-shelf when they can, invent when they must. The small secondary reflector attached to the front of each dish, along with the telescope's electronics, is covered with a shroud that's fabric on top, aluminum below. The project's engineers had to test all kinds of fabrics before they found one that kept out water but let in radio waves.

Tarter opens the shroud from the aluminum bottom and we poke our heads up inside, where we're hit by a blast of hot air. Temperatures in the valley routinely top 100 in summer, and the sensitive electronics have to be kept cool (mini-refrigerators used in cell phone towers turned out to work nicely).

Inside the shroud is a spiky, silver-gold device that looks like an artificial Christmas tree. This is the telescope feed, which Tarter says reminds her of something from Flash Gordon. This particular design is another ATA innovation, and a crucial one. The feed is where radio energy collected by the dish is focused and converted to a signal containing the multi-frequency SETI data, which is then sent via fiber-optic cable to computers for processing.

The brains of the telescope array are inside the computer building. That's where digital signals from the individual telescopes are sorted and manipulated, turning this field of small dishes into a large and powerful phased array (see "How Things Work: Phased-Array Radar," June/July 2006). Because radio waves from a target star reach any two telescopes at

SETI INSTITUTE (2)

Jill Tarter can't give odds for contact, but quotes a 1959 paper on SETI: "If we never search, the chance of success is zero."

slightly different times, the peaks and troughs of the waves are slightly out of synch, or phase. The SETI computers can artificially shift the phases to match up, effectively combining the waves and boosting the signal. Or, equally useful, a signal can be canceled out by phasing up the troughs in the waves. That enables the team to filter out, for example, an annoying, beeping satellite known to pass over Hat Creek every night, which otherwise might be mistaken for a broadcasting alien. For a computationally intensive program like SETI, that's huge.

The more antennas, and the more random their pattern (hence the deliberately scattered placement), the better the technique works. "It's a lot of vector algebra, that's all," says Tarter. Her bachelor's degree from Cornell was in engineering physics, and she's very much a hands-on experimentalist. I ask her if, despite the workload, she likes all the tinkering and testing. "Sure," she says. "The frustrating thing is, I want it now. There are observations I want to make."

In fact, now that the first section of the array is in place (the 42nd antenna was installed in February), the ATA will make its first observations this summer. The dishes will be pointed toward the center of the Milky Way galaxy, which is thick with stars. The bad news is that most of them are extremely far away—the most distant extraterrestrials would need a transmitter 20,000 times more powerful than Arecibo's to be heard. It's a long shot, but worth trying while the array is still under construction, partly because such a broad survey has never been done.

SETI INSTITUTE

The array's first phase of 42 telescopes was completed this year. To build the full observatory, the SETI Institute will need a lot more money.

The ATA will monitor a million stars with enough sensitivity to detect an Arecibo-size transmitter 1,000 light-years away.

Meanwhile, the catalog of candidate stars (those most likely to be orbited by habitable planets) has grown to 250,000, and will eventually reach 1 million by the time the array is finished. As for when that might be, it depends on money.

"We're struggling, absolutely struggling," Tarter says on the subject of fundraising. So far, the man for whom the array is named, Microsoft co-founder Paul Allen, has bankrolled the project to the tune of $25 million. His last donation came in the form of a challenge grant, which would fund the array through 206 dishes if the SETI Institute could raise $16 million on its own. It fell $7 million short. The deadline was extended, but the institute is still about $30 million away from financing the full 350-dish array. And the longer it takes to raise the money, the longer the delays in construction, and the more expensive it all becomes.

Between the telescope testing, the software debugging, and the money worries, Tarter doesn't have a whole lot of time to think about alien contact. That's another odd thing about SETI: Even though a positive result would be among the most exciting discoveries in human history, there's a good chance that the content of any message would be indecipherable. We'd know only that someone is out there, trying to communicate. And that would begin a whole new field of inquiry.

It's hard to predict if or when that day will come. But should the ATA scientists ever hear a signal and verify independently (and in confidence) that it's not from Earth, here's what would happen: First they'd have their own private celebration. Every time the Phoenix team lugged its equipment to a radio telescope in Puerto Rico or Australia, says Tarter, "we always brought along champagne and kept it on ice." Then, as a courtesy, they would inform the major ATA donors. After that, they'd e-mail an official notice to the scientific community describing the discovery. They'd also send off a scientific paper to an astrophysics journal. Much of that paper is already written; only the details are missing.

Then they'd call a press conference.

Alenia's

ITALY'S AIRPLANE MANUFACTURER STAKES ITS FUTURE ON COMPOSITES.

Gamble

BY JOE PAPPALARDO

SEEING CARBON composite material in its raw form makes it very hard to imagine airplanes built from the stuff. In a brand-new Alenia Aeronautica plant in southern Italy, just outside a town of artisans and olive groves called Grottaglie, hundreds of foot-long spools of paper-thin, half-inch-wide strands wait to be transformed. The material looks like dull-black electrical tape and feels like brittle typewriter ribbon. Wrap those strands around a mold and bake them under pressure in an autoclave, however, and they will meld into a single, super-strong piece of carbon-fiber-reinforced polymer resin, the material that promises to revolutionize the way people make airplanes.

In Grottaglie, the carbon fiber will be used to create two center sections of the fuselage of Boeing's newest commercial airplane, the 787 Dreamliner. With Japanese and U.S. suppliers building the forward and aft sections from the same material, the airliner's entire pressurized hull will be made of composites, an industry first.

Alenia's supply of spools occupies a small fraction of the floor space in a massive clean room, the largest in Europe (at 6.2 million cubic feet, the equivalent, Alenia calculates, of a 3,000-room hotel). The room is protected from dust by reverse-pressure doors. The temperature and humidity are vigorously controlled at 66 degrees Fahrenheit and 60 percent, respectively. If the air were more humid, the moisture could infiltrate the raw polymer, then, as it cooks away during the curing process, leave destabilizing air pockets. If the air were warmer, the resin embedded in the material could start to soften, causing the strands to stick together. In protecting against these hazards, plant managers have made the clean room the most consistently cool place in the entire air-conditioning-averse nation of Italy.

Everyone in the room—supervising executives, engineers testing materials, construction workers assembling manufacturing equipment, gawking visitors—is wearing a white paper lab coat, preparing for the first tests of the composite fuse-

OPPOSITE: BOEINGMEDIA.COM; RIGHT: COURTESY STUDIO AMATI

Composite fuselage sections (opposite) for Boeing's 787 are being made in four factories around the world, including a new Alenia facility in Grottaglie, Italy (right).

FLAVIA NEGRETTI

Composites chief Maurizio Rosini will eventually supervise 800 workers (and huge machines) churning out airplane parts in Grottaglie.

lage sections, just ahead of initial production. Towering pieces of machinery, designed to craft the 28- and 33-foot-long parts of the Dreamliner, stand like set dressing for the 1927 futurist film *Metropolis*. In fact, everything here is shockingly large, including the stakes. Alenia Aeronautica has invested more than $600 million in the Dreamliner program, most of it spent on this facility and fuselage barrel development. Company executives are betting the investment will net much more than the $1.1 billion contract the company has with Boeing for Dreamliner sections.

The immense responsibility for getting operations here off to a smooth start rests on the slight shoulders of Maurizio Rosini, the chief operating officer of Alenia Composite, a subsidiary formed to spearhead the manufacture of major aircraft structural components from carbon fiber. Rosini has pale skin and white-gray hair. He also has a quick mind, an unflappable demeanor, and an office in each of the three Alenia airplane plants building carbon fiber components. These days, he says, most of his time is spent in this new, gigantic facility in Italy's boot heel, which employs about 500 and is remaking Grottaglie into a center of the global aeronautics industry.

"This is a new plant, using new machines and new technology," he says, peering at visitors intently from behind the thick lenses of his glasses. Rosini has the Italian tendency to grip the crook of a listener's arm to emphasize his points, and does so now, his other hand gesturing at a machine that is bigger than some apartment buildings, rising 118 feet above him. "Look there: Something is happening," he says.

Behind a clear panel, 32 spools of the carbon fiber begin spinning within the machine. When the factory is ready the following week, the spools will layer the material on a 30-foot mold, or mandrel. The mandrel gives the raw material its final shape.

The composite ribbons unwind in a dizzying mix of computer-controlled patterns to fully coat the mandrel, ply after ply. Exactly how many layers, their total weight, and their pattern neither Boeing nor Alenia will disclose. The first to use composites for as much as 50 percent of an airliner, the 787 builders are very careful not to give away secrets.

"This is a tremendous change," says 787 program director Guglielmo Caruso, based in Alenia's headquarters in Rome. "These new aircraft will have the same dramatic impact as the passing from wooden airplanes to metal, or propellers to jets."

If Caruso is right and the future is in composites, then Alenia Aeronautica's fortunes rest on the company's performance during the Dreamliner contract. Alenia must get a factory up and running in time to meet the relentlessly demanding schedule of the 787 program, which requires the coordination of major partners in three nations. Boeing and its partners have committed to delivering 112

> "This is a tremendous change. These new aircraft will have the same dramatic impact as the passing from wooden airplanes to metal, or propellers to jets."
>
> – GUGLIELMO CARUSO, ALENIA'S 787 PROGRAM DIRECTOR

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Making airliners requires enormous tooling, like the structure (left) that holds fuselage barrels for inspection, in immense factories (below). Natural light streams in from the 80-foot ceiling.

The 787 nursery? At a Toray Composites factory in Frederickson, Washington, a technician tends the carbon ribbons that will one day form the structures of airliners.

ABOVE: ELLEN M. BANNER/THE SEATTLE TIMES

Dreamliners by the end of 2009. The first deliveries, to All Nippon Airways, will begin next May, about a year and a half away from Alenia's pre-production tests. For the aeronautics executives in charge of the daily grind, this is a career maker or breaker.

During a tour of the plant last October, Rosini was bearing the balance of risk and excitement comfortably. Only with considerable prodding did he admit that at night, during his frequent overnight stays near the plant, about 200 miles away from his family in Naples, he could not stop thinking of the long list of tasks that needed to be done at Alenia's giant facility.

HUNDREDS OF ENGINEERS from companies in Japan, Italy, and the United States worked from June 2003 to October 2005 at Boeing's facility in Everett, Washington, to lock in the final design decisions for the 787. Boeing had determined the requirements: The Dreamliner would seat 250 passengers and fly with ranges and speeds comparable to those of wide-body ocean-crossers like the 747 and 777. It would be economical to operate and maintain because it would be built of lightweight composites (and have super-efficient engines, not then designed). Engineers from all of Boeing's first-tier contractors figured out how to meet those requirements.

With the Dreamliner, Boeing implemented an even more collaborative approach to building an airliner than the engineering process it used on the 777, famous as the first airliner to be designed and "mocked up" entirely by computer. On the 777, the engineering was concurrent; Boeing gave customers, subcontractors, even maintenance professionals access to computer design files so that problems from any of those quarters—"We can't build this part that way" or "I can't reach that light to replace it"—could be worked out in the preliminary phase, before a single rivet was fastened.

On the new airliner, Boeing involved its suppliers not just in the design but in the development of the technology required to build the airplane.

"With the 787, we involved [major contractors] earlier and deeply in the development process," says Bob Noble, the director of 787 operations within Boeing's supplier organization, Global Partners. "It allowed us to learn from one another in new ways and allowed very focused investments that will have long-term benefits to the program. I can't imagine ever doing a program without this kind of partnering."

Both Boeing and Airbus—the only true prime manufacturers left in the cutthroat airliner industry—have changed the way they work with subcontractors. Instead of hiring a company to supply, say, a wing, the prime asks for the wing plus all the subsystems within it. The giants provide coordination during planning but minimal guidance during execution. They oversee only the first-tier contractors—and expect those contractors to oversee the long chain of suppliers.

"In the new business model, they want to be the guy at the end of the day that

FIND OUT MORE ABOUT THE ROBOTS THAT HELP BUILD AIRCRAFT AT ALENIA AERONAUTICA FACTORIES. VISIT [illegible]

just snaps the components together," says Eric Hugel, who analyzes the aviation industry as vice president of the U.S. investment bank Stephens Inc.

Alenia Aeronautica (a descendant of airplane builders Fiat and Aeritalia) was an obvious choice to be a major player in the 787 program. Besides developing and supplying the outboard flap for the 777, the longest piece of composite structure on the aircraft, Alenia supplied subassemblies for three earlier Boeing airliners and has been a partner on the tanker/transport version of the Boeing 767 since 2001. Partnering with Alenia has helped Boeing reach European buyers; the Italian air force ordered four 767 tanker/transports at about the same time Boeing and Alenia signed the partnership agreement.

Besides fabricating fuselage barrels for the 787, Alenia is tasked with designing and manufacturing the horizontal stabilizer, and also performs static and fatigue trials on the piece. Alenia is the only supplier engaged in this level of complex testing on Boeing's behalf. The fabrication work is being done in a plant in the town of Foggia, while the testing is done at a facility outside Naples.

As part of the state-owned conglomerate Finmeccanica, Alenia has sometimes suffered from the layers of bureaucracy and political pressures imposed on a nationalized industry. In Italy, as elsewhere in Europe, politics directly affects a company's strategy. Through a process known as *concertazione* (consensus formation), in 1993 labor unions secured a powerful voice in the government's formation of economic and social policy.

"The system operates to discourage changes such as relocations and the entry of new firms," wrote Edmund Phelps, last year's Nobel Prize winner for economics, in an opinion piece for the *Wall Street Journal*. "What it lacks in flexibility it tries to compensate for in technological sophistication."

That philosophy explains the large investments—courtesy of the Italian taxpayers—in cutting-edge machines and techniques. "We looked around the world for partners who understood composite technologies, had experience with commercial airplanes, and had the corporate will to engage in a complex industrialization effort," says Noble of Global Partners. "Alenia fit the requirements."

The speed at which the company has moved on the Dreamliner project defies the image of a plodding Italian company, made sluggish by politicians and bureaucrats. A year and a half after its groundbreaking, the Grottaglie manufacturing center, with an area the size of two dozen American football fields and 40 million pounds of structural steel in its bones, produced the first pre-production fuselage sections for the 787. "I think Boeing was surprised by the speed," says Antonio Perfetti, Alenia Aeronautica's chief operating officer. "This was not expected from 'those Italians.' "

Nor was this the first time "those Italians" had done something out of the ordinary. Airbus Industrie, a consortium of European-owned aviation companies, has long courted Alenia to become a full partner, but the company has steadfastly (yet politely) refused. Hugel points out that Alenia is sacrificing the security that comes with such a permanent partnership: "It's a 'sure thing' versus a risk that you'll get nothing."

Alenia has developed new manufacturing capabilities and experience to be attractive to both Airbus and Boeing. "The investments for these new technologies are huge," Hugel says. "Why apply them to only 50 percent of the market when you could get 100 percent?"

Alenia has joined with EADS to produce the ATR regional turboprop and has supplied components to almost every airliner in the Airbus family. It is a partner with U.S. military contractor Lockheed Martin on a medium tactical military transport, the C-27J Spartan. It built the composite wings of EADS' Eurofighter—experience that helped convince Boeing that the company knew how to work with composites. Most recently, Alenia formed its own joint venture—with Vought Aircraft Industries in South Carolina. The new company, Global Aeronautica, will join the 787 sections being manufactured around the world.

Alenia's willingness to dance with any partner has earned the scorn of European governments that treat their state-owned industries as tools of diplomacy. That's where Alenia's manufacturing capabili-

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In Alenia's autoclave (right and below), the largest in Europe, fuselage barrel sections are cured at high temperatures and pressure.

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The unlovely head of a fiber placement device (left) is what cocoons a barrel-shaped mandrel (not shown) in carbon fiber. So the head can reach all sides, machines (above) rotate the mandrel as fiber is applied.

ties come into play. Because of the company's factories and its broad experience, European and U.S. companies alike have continued to ask to become partners.

"In the past we were accused of being a two-faced company. I think this is a very stupid criticism," says Perfetti. "What was once perceived as a negative is now perceived as a point of strength."

A year and a half after its goundbreaking, the Grottaglie manufacturing center, with an area the size of two dozen American football fields, produced the first pre-production fuselage sections for the 787.

Alenia's partnerships are not permanent alliances, like those in the Airbus consortium; they are based on individual products, what Giorgio Zappa, former company president, called "opportunistic partnerships." Company officials today credit Zappa, who became chief operating officer of Finmeccanica in late 2004, with resisting a monogamous relationship with Airbus and forging Alenia's independent direction.

WHEN ALENIA WAS breaking ground for its new aircraft factory in 2005, Grottaglie was best known for olive oil (the dark, unfiltered kind) and ceramics. Grottaglie's residents have not yet caught up with their town's transformation into a center of heavy manufacturing wizardry. Their favorite pastimes seem to be peering out of doorways and making plates decorated with saints or roosters. Rows of gnarled, thousand-year-old olive trees separate the town from the three massive factory buildings, all colored Alenia blue. The trim of the door and windows, the outside stairs, and the fences are all the same hue; the company is aware of the power of branding. New grass grows around the entrance.

Inside the main building of the manufacturing center, natural light pours from the ceiling 80 feet above, bathing new industrial machinery. Great empty spaces surrounding the machines will one day be occupied by duplicate pieces of equipment, if the contracts multiply. "Automation is key for one-piece technology," Rosini says, referring to the innovative method of making whole, circular sections. "We will reach a very high rate of production in a short time. The days of slow starts are over."

The clean room, where the most delicate work will be done, takes up about a third of the building. "The clean room area is the heart of the building," Rosini says. "And the heart of the process is the mandrel."

The mandrel is etched with the precise details of the fuselage, including recessed shapes that later will be cut to form the doors and windows. Unlike the mandrels used by other Boeing partners, Alenia's has been designed to collapse, freeing the composite form without the need to disassemble the underlying structure. Think

COURTESY ALENIA AERONAUTICS

After the weaving, baking, and inspecting were done, workers prepared Alenia's first production fuselage section for shipping.

IT HAS TAKEN 40 YEARS for the aviation industry to grow comfortable with carbon fiber composites. A matrix of resin infused with ribbons of carbon is a material of great strength and negligible weight, compared to metals. But airplane makers are conservative, and they only very gradually replaced aluminum, which they understand well, with composites, which they are still testing. Composites first appeared on airliners in the mid-1960s in secondary structures, such as wing-body fairings and control surfaces. In the late 1980s, Airbus and Boeing began to use composites for primary structures: tail surfaces. But not until the 787 enters service will composites form an airliner fuselage, subject to the thousands of pressurization cycles airliners experience in a lifetime as they climb to cruise and descend to land.

Is It Tough Enough?

Airline passengers needn't worry about the new use, according to Mike Hoke, president of Abaris Training in Reno, Nevada, which trains technicians in the manufacture and repair of advanced composites. "Composites do quite well under tension loading, where you're trying to stretch the fibers," he says, "and that's what pressurization does. Pressurization tries to blow the fuselage up like a balloon.

"Composites don't propagate fatigue cracks like metal structure," he continues. "Engineers inflict various levels of damage [to a structure] and subject it to thousands and thousands of load cycles to prove that the damage doesn't get any bigger."

But the material poses its own set of challenges. Small breaks are inevitable, and carbon composite skin is so elastic that it could reform outwardly, hiding any cracks within the material. Justin Hale, Boeing's deputy chief mechanic for the Dreamliner program, says the company quickly ruled out creating new ways to find small internal flaws, which would require expensive non-invasive scans, such as ultrasound. Instead, Boeing engineered the structure to perform well despite damage and opted to "add a lot of margin of error to account for hidden damage," Hale says. (The word "hidden" means the Federal Aviation Administration's standard: At five feet, in typical lighting, the damage cannot be seen with the naked eye.)

To prove the robustness of the aircraft's engineering, the company launched, "by a factor of two, the largest structural test program ever done by Boeing," says Hale. "The fuselage drove a lot of that."

"Test engineers pretend that repairs are never done," says Mike Hoke. "When engineers put structures through load and flex testing, they cut a bunch of holes in the structure. If the structure survives the tests, they're not too worried about the repair."

The major area of concern, Hale says, is damage from accidents both large and small. Boeing designed the 787 with energy-absorbing features and will have to prove that it "meets or exceeds the crashworthiness performance of current widebody transport aircraft made from aluminum," says FAA spokesman Les Dorr. "This is an instance where the FAA and Boeing are working together to develop new requirements through test and analysis to address differences between composite and aluminum fuselage designs."

Boeing must also show that the 787 can survive daily wear and tear. "This is the first time we've moved the carbon [composite material] into areas where you see daily abuse," Justin Hale notes.

To demonstrate that the 787 will not have to be handled more gently than aluminum, Boeing devised seven real-world accident scenarios in which to test composite material, including smashing a wingtip into an immovable object, ramming the airplane with a luggage hauler and a galley service cart, and having the nose gear collapse. Engineers then calculated how much time and money would be needed for repairs. The most severe wounds would require a cut-and-patch job using a kit, which Boeing has developed, of carbon patches and liquid resin.

In addition, the 787 fuselage is built so that quarter sections can be removed. In the unlikely event that a 787 sustains damage that can't be patched, Boeing will have replacement sections ready.

of melting a candle over a balloon, and then deflating the balloon to separate the layer of wax in one shaped piece from the template beneath it. The design saves production time and preserves the details of the form.

The composite material, delivered to nearby Brindisi airport in refrigerated cargo airplanes, is loaded into a machine that dispenses the fiber. The machine's robotic arm, suspended from a gantry, moves along the length of the mandrel, laying the carbon fiber strips with absolute precision. The mandrel rotates to give the robotic arm access to all sides. A scaffold surrounds the mandrel, and stairs allow technicians to monitor the placement machine's activity.

The head on the robotic arm does not appear to be very dextrous—a clamp, guide wheels, and loops of wire. But the device weaves about 85 feet of fiber per minute, using laser guidance and computer software to cast the composite tape with the speed and spirit of an orb spider spinning a web.

The fibers of a single ply point in one direction, but the fibers of the next layer run in another direction to make the skin resistant to bending forces (just as the layers of wood fibers in plywood are laid in

At its Future of Flight Aviation Center, a $23 million tourist attraction 30 miles north of Seattle, Boeing shows off a 787 barrel section.

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alternating directions). The thickness of the composites throughout the airplane varies from one-quarter inch to more than an inch, depending on the load each area must bear. No matter where on the composite form stress is imposed, there will be a pattern of plies that is especially resistant to it.

The placement and orientation of the fiber strips are not the only way to handle stresses caused by openings in the fuselage structure—doors, windows, and other holes. The composite skin is reinforced by composite ribs called stringers, which run longitudinally to stiffen the weaker areas adjacent to the openings. An automated system of cranes within the towering fiber placement machine places the long carbon fiber stringers on the mandrel before "lay up" of the fibers. There are more than 100 stringers in each fuselage component.

Between uses, the mandrel stands as passive as an Easter Island statue. It is made from a nickel alloy, which is stable in extreme temperatures. When the composite piece is fired at 350 degrees Fahrenheit, the mandrel will be heated too, and it must not bend or buckle during the process. "In all other materials there is deformation, and we must be very precise," Rosini says. All pieces must be within a tolerance of 0.3 millimeter.

An automated vehicle ferries the composite form and mandrel slowly toward the autoclave. Before leaving the clean room, the form is covered by a bag to keep impurities out. At 64 feet long, the autoclave is Europe's largest. The barrel slips into the oven like a shotgun shell into a chamber. The oven's round door looks like it belongs at the blast-hardened entrance of a NORAD bunker. It is, of course, painted Alenia blue.

The strips of carbon fiber material are impregnated with resin, which will ooze out when heated in the autoclave to form the matrix—the binding substance in a composite that holds the reinforcing elements, in this case polymer resin that holds the strips of carbon fiber. In the finished product, the resin matrix will serve as a bridge to ferry the stress of a load across a break if the carbon fibers snap. The heat and pressure of the autoclave are vital for the stability of the final product. The heat melts the resin, which is designed to retain its form when it softens, unlike a common plastic. The pressure drives out air pockets by pushing the resin into any microscopic voids that may lie between the carbon strands. Air pockets could create weak spots, forming cracks that could spread and jeopardize the entire piece.

After a 16-hour bake, the mandrel is removed from the autoclave, and the heat-resistant bag is removed.

The mandrel and now-cured fuselage section stay connected as they are brought to a 160-foot-long machine that shaves away composite to create openings for windows and doors. Several days after the process started, the form is placed into two fuselage-size rings—think *Stargate*—that will preserve its shape once the mandrel is collapsed and removed. The rings hold the not-yet-rigid airplane section while the work continues and quality control inspections begin.

When the sections are finished, Boeing's modified 747 freighter, the unsightly Dreamlifter, will fly them to the new Alenia-Vought plant in North Charleston, South Carolina. There, approximately 350 workers will assemble, integrate, test, and apply surface finishes before sending joined sections on to Everett, where all the pieces will be put together.

As Alenia begins production of 787 parts, it is also negotiating a role on the 787's rival, the Airbus A350. For the Boeing contract, the company benefits from a happy accident of geography. The 787 project demands time-zone straddling conference calls between South Carolina, Japan, Everett, and Italy. The best time to get all the partners together at once, Caruso notes, turns out to be daytime in Italy. "We are in the best location for conference calls," he says. In other words, he feels Alenia is right in the middle. Just where it wants to be.

Last March, Alenia shipped the first fuselage sections from Italy to its assembly facility in North Charleston, South Carolina. Two sections down, and hundreds to go.

COURTESY ALENIA AERONAUTICS

Flight Lines

by Mariana Gosnell

HOW AIRPLANES MAKE CLOUDS.

IN JOHN FORD'S LAST WESTERN, *Cheyenne Autumn*, long threads of white cross the sky over army tents in Monument Valley, along the Utah-Arizona border. In the 1993 film *Gettysburg*, a brilliant white sliver hovers in the clear sky above the head of a Union officer. In *Zulu*, a dramatized account of the 1879 assault by thousands of Zulu tribesmen on a small British garrison in Natal, South Africa, whitish bands sometimes hang in the sky beyond the hills.

Nitpickers who enjoy finding movie bloopers point out that these man-made cirrus clouds are condensation trails, or contrails, which didn't exist before the 20th century. They are created by airplanes flying at high altitudes, where the air is below –38 degrees Fahrenheit. Exhaust from airplane engines contains water vapor as well as other gases and particles of soot and metal. When the exhaust is expelled into and mixes with the cold air, the water vapor condenses into droplets, which instantly freeze into tiny ice crystals. What you see from the ground is a dense white stream of ice crystals behind an airplane.

Sometimes an airplane leaves no contrail at all, or an extremely short one—an indication that the air at cruise altitude is probably dry. There must be enough water molecules in the air to condense and freeze—in other words, the relative humidity must be 100 percent or greater. In dry air, any ice crystals that form would immediately evaporate.

Even if the air is moist enough, it might not be cold enough. At typical contrail-friendly altitudes, between about 28,000 and 40,000 feet, temperatures run from about –36 to –76 degrees. If the airplane leaves a long trail, you can assume that the air is not only cold but humid, allowing the ice crystals to persist. If the contrail stops, then starts up again, creating a broken line, chances are the airplane flew through a dry patch.

Immediately behind the airplane, between the tail and the head of the contrail, is a 100-foot stretch of clear air, representing the short time it took for ice to form from the mixture of hot exhaust and cold ambient air. You might see four white lines at first, or two, since each engine produces its own contrail, but before long they merge into one line. The line is likely to have what Patrick Minnis, senior research scientist at NASA's Langley Research Center in Virginia and an expert on contrails, calls "structure"—striations or "puff balls"—produced by the spinning of the exhaust. "If the puff balls are close together,"

Opposite: High above Boston's Logan International Airport, a Continental Boeing 777 streams contrails near the dissipating tracks of another airliner. Below: A transport gets back on track after a graceful zig-zag over the north Atlantic.

EMMANUEL TAILLIET

OPPOSITE: MARK GARFINKEL

JAKUB VANEK

Contrails trace what looks like a terrifyingly close call, though it's perfectly legal: A thousand feet separates these airliners over Prague, Czech Republic. A telephoto lens foreshortens the distance between them.

Minnis says, "you might not notice them, but they're almost always there."

A lot of other things can happen to a contrail once it's formed. Winds can move it along, widen it, fray its edges. If contrails grow large enough, crystals will fall into a drier layer below, where they evaporate, or fall into a saturated layer, where they may split and trigger the formation of more crystals. If there is wind shear, the crystals in the lower layers move at a different speed than their cousins above. "Typically, this will end with a contrail spreading horizontally and vertically," Minnis says. "There have even been reports of crystals making it all the way to the ground."

It's not only jets that make contrails; piston aircraft do too. So do rockets. So, apparently, do birds. "I have heard of wild geese leaving vapor trails high over the Canadian Rockies," Guy Murchie wrote in his book *Song of the Sky*. A goose exhaling warm, moist air into –38-degree air could produce a contrail, Minnis allows, although "it would certainly be a small one."

The first recorded sighting of a contrail likely occurred in southern Tirol in the Italian Alps in 1915 when somebody named Ettenreich spotted "the condensation of a cumulus stripe from the exhaust gases of an aircraft"; the stripe stayed around for a while. It wasn't until World War II that anyone took interest. In a single combat area, hundreds of aircraft sometimes generated so many contrails that pilots couldn't see to keep in formation or find a target. "We were, in effect, clouding the sky over Germany," wrote 34th Bomb Group member Hal Province to Veritas News Service reporter Jay Reynolds in 1999. Contrails could be used as cover for an attack: "Four Me-262s came in hidden by the contrails and hit four of us," Richrad Scroxton wrote in a 1983 account now posted on the 100th Bomb Group Web site. Even more troublesome, contrails gave away aircraft positions. "We were easy for them to spot, as our contrails were heavy that day," another bomber crewman noted, "pointing like fingers in the sky toward our squadron," Mike Banta wrote in 1997 in an account of his B-17's last mission, now posted on the 91st Bomb Group Web site.

ISMAEL JORDA

The finger-pointing problem has yet to be solved. In the early 1990s, after the U.S. military developed the B-2 stealth bomber, it again became interested in contrails. Steve Weaver, a senior meteorologist at Wright-Patterson Air Force Base, Ohio, points out: "They spent all this money to develop a billion-dollar bomber that's invisible to radar, but you can see its contrail with your naked eye." The original B-2 design included a tank outboard of the main landing gear that would store a chemical to mix with the

exhaust and suppress contrail formation. The Internet is a rich source of speculation as to what went wrong with that plan, but in the end, Ophir, an optical sensor manufacturer in Littleton, Colorado, saved the day. Its Pilot Alert System uses lidar (light detection and ranging) to differentiate contrails from clouds and tell the pilot to change his altitude when his aircraft is "conning."

Erik Mathieson, a former Air Force pilot who today flies an Airbus A330, appreciates contrails. "They tell you if the airplane ahead of you at a similar altitude is getting a smooth ride—the line doesn't undulate or dissipate rapidly—in which case you can expect a smooth ride too," he says. "If there are several aircraft on closely spaced parallel tracks, contrails can let you know which altitudes are choppy and help you decide whether to climb or descend."

There are those who consider contrails to be downright sinister: noxious chemicals sprayed from aircraft to sicken populations and alter weather patterns, according to conspiracy theorists. The claims seem to rest on the notion that thin, short-lived contrails may consist of ice crystals, but the thicker, long-lived ones are not. In reality, the expanded lines are merely contrails that have evolved.

When U.S. air traffic was grounded for several days after the September 11, 2001 attacks, and the only contrails on satellite images were ones made by six military aircraft, NASA had a chance to see the difference the streamers make. Within five hours, the contrails from the six jets had expanded to cover 8,000 square miles.

If the air at cruise altitude is humid enough, a contrail can extend for hundreds of miles and last for hours. A NASA researcher once tracked a contrail for 17 hours, until it lost its shape and merged with other clouds.

Buried at the Bottom of the World

SIXTY YEARS AFTER A NAVY SEAPLANE CRASHED IN THE ANTARCTIC, A

SURVIVOR FIGHTS TO RECOVER THE BODIES OF HIS CREWMATES.

by Carl Hoffman

THE YEAR WAS 1946 and James "Robbie" Robbins was living large. He was 19 years old, tall and dark-haired, and already a World War II veteran with 1,500 hours in Martin PBM Mariner seaplanes. During the war he had patrolled the Atlantic Ocean, from the Caribbean to Greenland; now his territory was the North Atlantic. Though one war had ended, another—the cold war—was beginning, and the U.S. military was fanning out to all corners of the globe to prepare for wherever the next conflict might erupt.

Robbins flew as part of Project Nanook to establish Thule Air Base, scouting Greenland's North Star Bay one day, and the next flying a mail run back to Goose Bay, Labrador, and flirting with the nurses at the base there.

Late in the year, he went with the Navy to the opposite pole for Operation Highjump, at the time the largest expedition to the Antarctic ever conducted. Under the command of famed polar explorer Rear Admiral Richard Byrd, 13 ships, 23 aircraft, and 4,700 men were sent to photograph, map, and perhaps even claim the Antarctic continent for the United States. And there was Robbie Robbins, a radar man suddenly ordered to Panama to join the seaplane tender USS *Pine Island*, loaded with three PBMs and bound for the last continent. It was the start of a tragic adventure that would leave three men dead and six others stranded in the coldest, most inhospitable place on Earth for 13 days.

Now, six decades later, Robbins and relatives of the crewmen who died are trying to get the Navy to recover the bodies that were left behind.

AS ROBBINS REMEMBERS IT, on December 30, 1946, the *Pine Island* hove to in the lee of a giant iceberg not far from Thurston Island, about 40 miles from the Antarctic mainland and some 1,500 miles south of Punte Arenas, Chile, and went to work. The expedition had only the two months of the austral summer before weather would make photography and mapping impossible. With a hard blue sky and the weather cold and crisp, *George One*, as the first of the *Pine Island*'s three PBM-5 Mariners was code-named, was dropped in the water, fueled, and towed clear. It took off on a 10-hour mission, following the coast westward and photographing the shore. By the time Robbins' commander, Ralph "Frenchie" LeBlanc, had gathered his crew for the airplane's second flight, the weather had deteriorated slightly. But weather in that part of the world was always iffy. The crew

Maxwell Lopez, Wendell Hendersin, and Fred Williams (left to right) became the first Americans to die in Antarctica when their airplane went down in 1946.

ANTARCTIC LANDSCAPE BACKGROUND: STEVE BLOOM IMAGES/ALAMY; COURTESY LOPEZ, HENDERSIN, AND WILLIAMS FAMILY COLLECTIONS

Crewmen on the USS *Pine Island*, anchored off Antarctica (above), prepare a PBM-5 Mariner for flight during a snowstorm. Upper right: James Robbins (front row, right) poses with some of his shipmates. Behind him are Lopez (to the left) and Hendersin (to the right).

believed that the weather inland was clear; they figured they had a window and they'd better take it. The *Pine Island*'s captain, Henry Caldwell, anxious to get a sense of the place, wanted to ride along.

By the time crew members were readying *George One* for the second flight, the waves were thrashing, yanking the airplane against the lines that tethered it to the assisting boats and roughly jostling the guys inside. Robbins and Caldwell managed to attach four jet-assisted takeoff bottles to the seaplane, but the mooring lines were literally shredding the craft's aluminum skin. LeBlanc, another World War II veteran with thousands of hours in PBMs, was unperturbed by the conditions. The *Pine Island* laid a fuel slick to calm the waters and *George One* cast off and started its run. After what seemed like five miles, the longest run Robbins had ever experienced, LeBlanc fired the JATO bottles and *George One* took wing—into a blinding snowstorm.

Robbins says he wasn't worried, though. He had once received a commendation for a nine-hour flight through fog and clouds in Greenland, and he felt confident in his skills as a radar operator. As Captain Caldwell strapped into the seat in the forward gun turret—now just an observer's seat—Robbins checked his radarscope. Icebergs below registered strong returns.

As they approached the coast, Robbins reported to the flight deck: "Mountain range 20 miles ahead and scattered icebergs." The radar return was clear and strong; the terrain matched the charts. But the weather ahead wasn't clearing. LeBlanc and copilot William Kearns decided to abort the flight and began a long, slow 180-degree turn.

Robbins, standing between the pilots on the airplane's flight deck, felt a slight bump. He heard LeBlanc and Kearns pour on full power.

And then, nothing. He felt like he was floating. He felt a shaking. His shoulder. He looked up; he was kneeling in snow 20 yards from the cockpit, and the flight engineer, Bill Warr, was standing over him. "We're all screwed up, Robbie," Warr said. "I think we're the only ones alive."

Robbins looked around, dazed. Snow was blowing and whipping. To his right he saw the navigator, Ensign Max Lopez. In front of them was radioman Wendell Hendersin. Both men were dead. Much of the airplane was burning, the flames crackling and popping in the wind and snow. Robbins stood up—he seemed okay—and he and Warr made their way toward the burning remains of the flight deck. Kearns was crawling in the snow, his shoulder dislocated, his arm fractured.

Suddenly, a voice: "Get me out of here!" Kearns leapt up and ran into the flames,

Robbins (left) and Bill Warr connect jet-assisted takeoff (JATO) bottles to the waist hatch doors of one of their ship's seaplanes before a flight during Operation Highjump. The JATO bottles provided the speed a PBM Mariner (top) from the *Pine Island* needed to take off over choppy Antarctic waters. Opposite: The holder for Lopez's Navy identification card, one of the mementos saved by his family.

where he tried to unbuckle LeBlanc, who was hanging upside down in his seat, but couldn't get him out. Warr and Robbins rushed in, pushed Kearns aside, and dragged the burning LeBlanc from the wreckage.

Over the next few minutes, the rest of the crew showed up. Caldwell was uninjured but disoriented. Fred Williams, another flight engineer, was lying by the fire, his back broken, blood oozing from his mouth and nose. Owen McCarty, the airplane's photographer, crawled from the largely intact aft section with a severe gash on his head.

A lifetime later, Robbins is at a loss to explain how they coped. But they were young and strong, and they had been through a lot already. They went to work.

The airplane was mostly in three main pieces. The wings had come off almost intact. Twenty feet from the wings lay the burning flight deck. Forty feet from that lay most of the fuselage and tail section. The men weren't sure what had happened, but in a 1950 account in *Flying* magazine, Kearns wrote that they "decided that the plane's light impact on a ridge had ruptured one of the fuel cells. Fumes from the leaking gasoline must have been ignited by an electrical charge or by hot exhaust gases," causing *George One* to explode in flight.

The crew slid Williams onto a piece of decking, erected a lean-to, and made him as comfortable as possible without moving him. They tucked LeBlanc into a sleeping bag in the tail section and hunkered down with him. Caldwell, Warr, and Robbins shared a single blanket; they rotated, each one getting some time in the warmth of the center position. Time passed. When the snowfall eased, Caldwell, Warr, and Robbins ventured out. Williams was dead. Who would be the next?

In some ways, they were lucky. *George One* had been stocked like a pantry before a party, so food was not a concern. After three days, the weather cleared. The sky was cloudless and the sun blazed. The men were perched on the edge of a hill, with the ocean shimmering below. Looking around, they found more sleeping bags, boxes of cigarettes, a Brownie camera with film, and other supplies, including a sled and a nine-man life raft.

Days passed; the sun never set. Robbins snapped photos with the Brownie, and when he ran out of film, tucked the camera in his tent. He painted "Williams, Hendersin, Lopez DEAD" in big yellow letters on the PBM's wings. On the seventh day, according to Kearns' account, the survivors placed the dead men into graves near the wingtip. Caldwell conducted the burial service.

Finally, on the 13th day, a PBM appeared. Everyone shouted, waved, and set off smoke grenades, but the airplane continued on its way. Two hours later it returned; Robbins threw a bucket of avgas on the raft, piled high with flammable material, and struck a match. The thing blew so hard it singed his eyebrows. This time the airplane turned and headed toward the cheering men. There wasn't a more beautiful sight, Robbins says, than that big Mariner, wagging its wings. The pilot dropped a weighted note, which Caldwell read aloud: "If you can make it to the lake, form a circle. If not, form a straight line." The lake was 10 miles away.

Robbins remembers Caldwell asking "What do you think?"

"What other choice do we have?" said Robbins. The men formed a circle.

Then they bent to the task. They piled sleeping bags on the sled and laid LeBlanc on top. Robbins mounted the compass from *George One* on the sled's handlebars. With three men pulling the sled and one walking behind to guide it, they struggled toward the shore. They frequently stepped through the crust and sank in snow up to their waists. Not until they hit firm ground did the going get easier. Walking the 10 miles took them 24 hours.

As they neared the shore, a bank of fog rolled in, hiding the rescue craft. The PBM pilot revved the engines, and the men headed toward the sound. Soon two crew-

LEFT TO RIGHT: NATIONAL ARCHIVES; COURTESY LOPEZ FAMILY (2); U.S. NAVY PHOTO COURTESY OF THE JOHN D. DICKENS FAMILY COLLECTION; BACKGROUND: BRENT BLUE

A message painted on *George One*'s wing (above) reveals the casualties. Top: The tracking chart of the PBM that rescued the six survivors. Right: Lopez's flight log.

men from the rescue plane, who had come ashore on a raft, joined them. Everyone got into the raft and they paddled out to the PBM, boarded, and flew off to the *Pine Island*, where Caldwell was piped aboard with tears in his eyes. Robbins (who had forgotten the Brownie camera with its treasure of undeveloped photos) and the rest of the survivors were soon transferred to the aircraft carrier USS *Philippine Sea* and returned to Panama, then to Washington, D.C.

For six of the nine men who crashed on Thurston Island, life went on. Because of complications from his burns, LeBlanc had both legs amputated below the knee and lost the use of one arm. Robbins married his sweetheart and was transferred to San Diego. He retired in 1965 as a chief petty officer. Caldwell, who had been in the Navy 24 years at the time of the crash, eventually made rear admiral.

The Navy sent telegrams to the families of the dead men. Wendell Hendersin's family held a memorial service in

Sparta, Wisconsin, but with no body to bury, they placed no headstone to mark a grave. Fred Williams' family in Clarksburg, Tennessee, decided against holding a service. "It was just too painful. Nobody talked about it," says Williams' niece, Kate Williams Beebe, now 70. "It was like a closed door. Grandma and Granddaddy wanted his body back, but they knew he wouldn't be returning." Max Lopez's family, which held a memorial service in Newport, Rhode Island, in 1947, remained haunted by his loss. "My father was seven years younger than Uncle Max and idolized his older brother," says Ted Lopez, 42, who has his uncle's service scrapbook, a collection of clippings about the accident, and the Western Union telegram informing the family of his death. (Lopez is the *Air & Space/Smithsonian* graphic designer.) "My grandmother held a bit of a grudge and even once called the pilot, blaming him." According to relatives, Hendersin's mother asked for a grave at Arlington National Cemetery for her son, but her request was turned down by the Navy.

Back aboard ship, rescued crewmen (from left) Owen McCarty, Robbins, and Henry Caldwell recall their ordeal. Used extensively for Navy search and rescue, the PBM (opposite) had a top speed of 210 mph and a range of 2,240 miles.

And the older Robbie Robbins grew, the more agitated he became. He would read about U.S. forensic anthropologists combing the forests of Vietnam and bringing the remains of former MIAs home, while Lopez, Hendersin, and Williams were still out there in a frozen tomb.

ONE DAY A RETIRED Navy chief petty officer in Allentown, Pennsylvania, named George Fabik got a computer. Fabik, then 79, had spent his whole career in the Navy. He loved the service and was loyal to it, and, like Robbins, he believed that no one who died serving his country should be left behind. Fabik was surfing the Internet on his new computer when he stumbled upon a Web site on Navy patrol squadrons that mentioned two Navy airplane crashes, both resulting in unrecovered remains: a Lockheed P2V Neptune that had crashed on the Greenland icecap in 1962 and *George One.* Kenneth Terry, head of the U.S. Navy Casualty Office, had been researching both cases and his memos were posted on the site. In one, Terry wrote that the chances for a successful recovery of the *George One* remains "would be extremely good if teams from the Department of Defense's Joint POW/MIA Accounting Command central identification laboratory were employed." Terry noted that JPAC's lab maintains 18 recovery teams worldwide, including one specializing in cold-weather recoveries.

Too far and too expensive, the Navy decided for both cases, estimating the P2V Neptune recovery at $2 million to $4 million, according to Terry. And anyway, there was a bureaucratic problem: Neither the P2V nor *George One* was an accident of war; the crew fatalities were not, technically, missing or killed in action and thus did not fall under the jurisdiction of JPAC. But in August 1995 some exploring geologists stumbled onto the Greenland site and found the remains of at least two crew members on the surface of the snow. The *Washington Times* and Fox News picked up the story, and an embarrassed Navy hired a British contractor to help JPAC recover the remains, which it did without difficulty in September 2004. The cost: $239,000.

But what about *George One*? Fabik was both horrified and embarrassed that the Navy was equivocating at all, and he turned his attention to the forgotten airplane and its dead crewmen. Cost and convenience should have nothing to do with the issue, he figured. If the Navy could recover American bodies in Greenland, well, it ought to be able to get the ones in Antarctica.

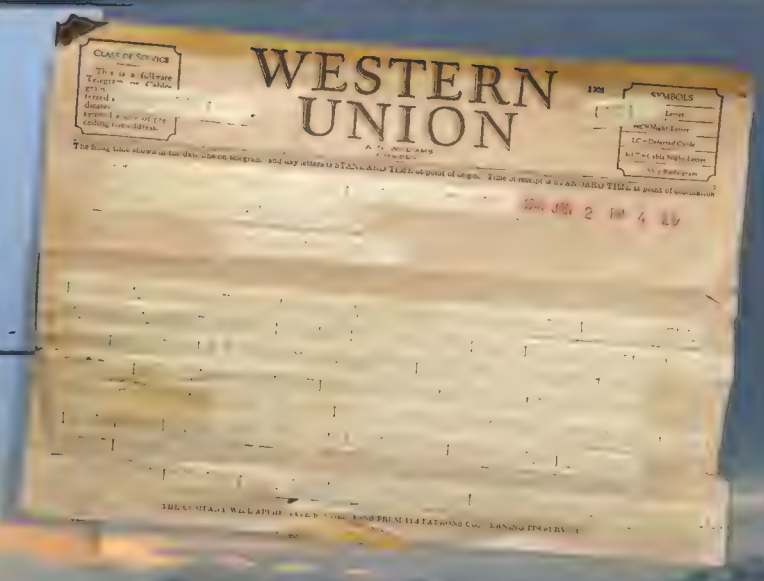
He got in touch with Robbins, and the sisters of Hendersin and Williams. He got in touch with Ted Lopez, and he started firing off letters to the Navy.

The Navy has recognized the sacrifice of Lopez, Hendersin, and Williams. Seven days after they died, their crewmates buried them in a service presided over by their ship's commanding officer, as would have been happened had they died during a World War II deployment requiring burial at sea. At the U.S. scientific base at Antarctica's McMurdo Station is a plaque—designed by veterans of Operation Highjump—honoring the three men as the first Americans to lose their lives in Antarctica; the National Science Foundation, which operates McMurdo, arranged for it to be placed there after the Highjump veterans' 50th reunion in Norfolk, Virginia, in 1996. The three names are engraved on a wall at the Navy memorial at the Presidio in San Francisco National Cemetery; the wall honors those killed in the Pacific theater. In 1960, at the request of the Navy, the Department of the Interior gave the name "Mount Lopez" to the unmarked and unnamed mountain that was the site of the fatal crash (Lopez was the highest-ranking serviceman killed). Still, the recovery in Greenland and letters from Fabik and Robbins spurred representatives from the Navy, the National Science Foundation, the Army, and the U.S. Geological Survey to meet outside Washington, D.C., in the fall of 2004. The first order of business: After nearly 60 years, could *George One* be located?

Jerry Mullins, the Geological Survey's manager of polar programs, found photos of the crash site in the National Archives and used them to narrow the search area to 0.5 square kilometer—124 acres. Satellite maps showed an area without crevasses, close to the ocean.

As it happened, a University of Kansas radar specialist named Prassad Ghogenini was in the midst of a project, under the aegis of the NSF and NASA, that used

LEFT TO RIGHT: U.S. NAVY PHOTO; NATIONAL ARCHIVES; COURTESY LOPEZ FAMILY; NATIONAL ARCHIVES; BACKGROUND: BRENT BLUE



A crane aboard the *Pine Island* (above) hoists a PBM from the water. Upper right: The telegram from the Navy notifying the Lopez family that their son was missing. Right: Robbins visits his badly burned commander, Ralph "Frenchie" LeBlanc, aboard ship.

Chilean navy P-3 Orions to map ice thickness. The NSF asked a P-3 crew to investigate during one of its flights. The airplane's radars registered strong returns over *George One*'s coordinates, suggesting metal. Ghogenini estimated the objects were buried under 150 feet of snow and ice.

In December 2004, Vice Admiral G.E. Hoewing, the Navy's chief of personnel, sent Robbins a letter. "Planning and coordination is currently underway for a recovery attempt from the *George One* crash site," Hoewing wrote. "If a plan is found achievable and approved, and funding is allocated, the initial phase...could be conducted late next year." In a personal note, Hoewing wrote: "Chief, we will do our best to recover your shipmates."

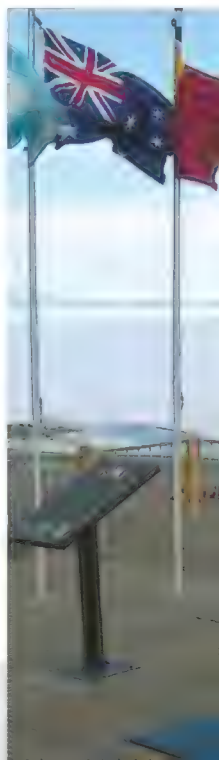
About this time, Bob Cardin, who had led the 1992 recovery of the World War II-era Lockheed P-38 Lightning *Glacier Girl* from beneath 265 feet of ice in Greenland, got a call from a Navy lieutenant commander whose name he can't remember. "I told 'em what kind of equipment they'd need, but they had no money," Cardin says. He never heard from the Navy again.

Unlike *Glacier Girl*, which was restored and flown in 2002 (see "Glacier Girl," Feb./Mar. 2004), *George One* is in pieces. And Antarctica is not Greenland. Greenland has U.S. military bases and commercial airports; any place on the massive island is a few hours' flight from anywhere else. Antarctica, on the other hand, remains the loneliest, most isolated place on Earth. Aircraft can fly in and out only two months of the year. Even then, as the doomed 1946 flight demonstrated, pilots can be flying in clear and windless weather one moment, only to find themselves in whiteout conditions a moment later. The only American fuel in Antarctica is controlled by the NSF, and its base at McMurdo Station is 1,250 miles from Thurston Island; Palmer Station, which the NSF also operates, is 1,005 miles away. The British base, Rothera, is closer, but it's still 799 miles off. The closest fuel cache on the continent—at a base known as Patriot Hills, 629 miles from Thurston Island—is owned by a private firm, Antarctic Logistics and Expeditions.

As for transportation options, there aren't many. The U.S. government operates two kinds of aircraft in Antarctica: ski-equipped C-130s belonging to the 109th Air Guard, out of Schenectady, New York, and privately owned deHavilland Twin Otters—operated by Kenn Borek Air, based in Calgary, Canada—which migrate south every Antarctic summer. With auxiliary fuel tanks, a Twin Otter's maximum range is 780 miles. Antarctic Logistics and Expeditions operates Otters and a Basler BT-67, a DC-3 modified with PT-6 turboprop engines.

Despite the challenges, the NSF operates in Antarctica throughout the year, using assets of the Navy, the Air National Guard, and private contractors. Scientists comb the continent, tourists fly in and out, explorers hike and ski its length and breadth. Recovering the men of *George One*, says Eric Chiang, the NSF's director of polar research and support, "is possible, and it could probably be done safely. It's just a matter of where one wants to put resources."

Chiang believes the weather around Thurston Island is too mercurial to fly a C-130 in. The job would require Twin Otters, which would need to lay a succession of fuel caches to reach the site. "You're talking about $30 a kilo out of Patriot Hills in an Otter," says Mike Sharp, owner and operations manager for Antarctic Logistics and Expeditions, "so that's $145,000 in and $145,000 out, for just one flight. You need a lot of fuel, a lot of people, hot water drills, a big camp, so it's a big, expensive operation." And, he says, if there's been any glacial



Next to a bust of Rear Admiral Richard Byrd at McMurdo Station, a plaque honors the crash victims.

shifting over the years, there's no guarantee the bodies will be intact. "If it were my tax dollars," says Sharp, an Englishman, "I'd say don't do it."

But the waters around Thurston Island can be relatively ice-free, and U.S. Coast Guard icebreakers make yearly runs opening channels for freighters supplying U.S. stations, then ferry scientists up and down the coast. The crash site was 10 miles inland in 1946, but as the island's ice shelf has receded, the site has slipped more than two-thirds of the way toward the sea. Theoretically, an icebreaker could sail close to shore, then deploy helicopters to haul equipment to the site. But again, the Navy would have to pay for the icebreakers, and they cost $23,000 a day. That's what Ken Terry proposed: a two-year plan to survey the site, take core samples, then return to recover the remains, estimating a total cost of $1.5 million to $2.1 million.

The Navy studied the options and decided against a recovery attempt. In July 2005, Admiral H. Denby Starling II, commander of the naval air force at U.S. Atlantic Fleet, informed Fabik of his decision. "We are fairly certain," Starling wrote, "that the radar reflection from the P-3 is *George One*, buried under 150 feet of ice. While technologies are available to dig to this depth, the mounting and execution of a mission of this type carries significant risk and would require technical expertise not available on my staff. Consequently, I recommended against my organization executing this mission."

"We just decided it was a physical impossibility," explains Commander Mike Maus, deputy chief of public affairs at Atlantic Fleet. "There's a greater risk going after it than [there is] getting it. If it's reasonable to do, we'll do it. But if it's not feasible, you're better off just leaving it where it is." The Navy estimated the operation would cost $32 million. Ken Terry calls the estimate "ridiculous."

And so, 60 years after Max Lopez, Wendell Hendersin, and Fred Williams died in service to the United States, it seems to come down to this: How much is a body worth? Must the Navy try to satisfy every family's deep cultural and emotional need to bid farewell to the remains of a loved one? Or can the service with a long tradition of burial at sea decide that recovery is just too costly? Lieutenant Colonel Rumi Nielson-Green, a spokeswoman at JPAC, says, "We have 80,000 still MIA from World War II and we have a budget. Do you spend all your money on one site and forgo hundreds of others?"

Fabik and Robbins, now 80, feel betrayed by Admiral Hoewing and the Navy they served for so many years. "He told me he was going to do it and then he retired," Robbins says. And the relatives of the dead men aren't giving up. Betty Jean Spencer, Hendersin's 80-year-old sister, recalls that during the 2004 presidential campaign, what were thought to be the remains of Democratic candidate Howard Dean's younger brother were recovered from Laos; why not her brother? Says Kate Beebe, Fred Williams' niece: "Somebody should try to get them. We go everywhere in the world looking for oil, but we can't retrieve those bodies? I think this should be one of the Navy's priorities, to bring back the remains."

Beebe, Spencer, Fabik, and Robbins are writing letters to the White House, their senators, the Navy. "I'm not going to stop until those men are home," says Fabik.

All of this is unsettling to Ken Terry, of the Navy's casualty office. "We know where the wreckage is," he says. "Recovering those men would be feasible. It's expensive, but it's the right thing to do. When that plane crashed, it was 10 miles from the coast. Now it's three, so the wreckage and the remains are slowly sliding to the coast and soon will fall off. I leave you with that."

OPPOSITE LEFT TO RIGHT: NATIONAL ARCHIVES; COURTESY LOPEZ FAMILY; U.S. NAVY PHOTO COURTESY OF THE JOHN D. DICKENS FAMILY COLLECTION; BACKGROUND: BRENT BLUE

Mission Impossible?

Bases with fuel caches are hundreds of miles from the crash site. A land-based recovery would require staging flights from one of these bases.

JUAN THOMASSIE

On October 4, 1957, a team of Soviet scientists and engineers launched a 184-pound aluminum sphere into orbit and began the Space Age. Fifty years after the launch of Sputnik, as plans for space exploration grow more ambitious, many of us still question why we do it, what compels us to bear the danger and the cost of venturing into space. NASA Administrator Michael Griffin recently offered a thoughtful answer, which we believe serves as a stirring introduction to our series of features celebrating the birth of the Space Age. —*The editors*

THE REAL REASONS WE

THE NASA ADMINISTRATOR CONTENDS THAT THE BEST REASONS

I AM CONVINCED THAT IF NASA were to disappear tomorrow, if we never put up another Hubble Space Telescope, never put another human being in space, people in this country would be profoundly distraught. Americans would feel that we had lost something that matters, that our best days were behind us, and they would feel themselves somehow diminished. Yet I think most would be unable to say why.

There are many good reasons to continue to explore space, which most Americans have undoubtedly heard. Some have been debated in public policy circles and evaluated on the basis of financial investment. In announcing his commitment to send the country back to the moon and, later, on to Mars, President Bush quite correctly said that we do it for purposes of scientific discovery, economic benefit, and national security. I've given speeches on each of those topics, and these reasons can be clearly shown to be true. And presidential science advisor Jack Marburger has said that questions about space exploration come down to whether we want to bring the solar system within mankind's sphere of economic influence. I think that is extraordinarily well put.

But these are not reasons that would make Americans miss our space program. They are merely the reasons we are most comfortable discussing. I think of them as "acceptable reasons" because they can be logically defended. When we contemplate committing large sums of money to a project, we tend to dismiss reasons that are emotional or value-driven or can't be captured on a spreadsheet. But in space exploration those are the reasons—what I think of as "real reasons"—that are the most important.

When Charles Lindbergh was asked why he crossed the Atlantic, he never once answered that he wanted to win the $25,000 that New York City hotel owner Raymond Orteig offered for the first nonstop aircraft flight between New York and Paris. Burt Rutan and his backer, Paul Allen, certainly didn't develop a private spacecraft to win the Ansari X-Prize for the $10 million in prize money. They spent twice as much as they made. Sergei Korolev and the team that launched Sputnik were not tasked by their government to be the first to launch an artificial satellite; they had to fight for the honor and the resources to do it.

I think we all know why people strive to accomplish such things. They do so for reasons that are intuitive and compelling to all of us but that are not necessarily logical. They're exactly the opposite of acceptable reasons, which are eminently logical but neither intuitive nor emotionally compelling.

First, most of us want to be, both as individuals and as societies, the first or the best in some activity. We want to stand out. This behavior is rooted in our genes. We are today the descendants of people who survived by outperforming others. Without question that drive can be carried to an unhealthy extreme; we've all seen more wars than we like. But just because the trait can be taken too far doesn't mean that we can do without it completely.

A second reason is curiosity. Who among us has not had the urge to know what's over the next hill? What child has not been drawn to explore beyond the familiar streets of the neighborhood?

Finally, we humans have, since the earliest civilizations, built monuments. We want to leave something behind to show the next generation, or the generations after that, what we did with our time here. This is the impulse behind cathedrals and pyramids, art galleries and museums.

Cathedral builders would understand what I mean by real reasons. The monuments they erected to the awe and mystery of their God required a far greater percentage of their gross domestic product than we will ever put into the space business, but we look back across 600 or 800 years of time, and we are still awed by what the builders accomplished. Those buildings, therefore, also stand as monuments to the builders.

The return the cathedral builders made on their investment could not have been summarized in a cost/benefit analysis. They began to develop civil engineering, the core discipline for any society if it wishes to have anything more than thatched huts. They gained societal advantages that were probably even more important than learning how to build walls and roofs. For example, they learned to embrace deferred gratification, not just on an individual level, where it is a crucial element of maturity, but on a societal level, where it is equally vital. The people who started the cathedrals didn't live to finish them. The society as a whole had to be dedicated to the completion

EXPLORE SPACE
ARE NOT ALWAYS LOGICAL.

by Michael Griffin

Ambitions to be the best led to (above, left to right) the Soyuz rocket, the first Earth orbit by Yuri Gagarin, the Apollo program, Viking missions to Mars, the U.S. space shuttle, and the International Space Station.

of those projects. We owe Western civilization as we know it today to that kind of thinking: the ability to have a constancy of purpose across years and decades.

It is my contention that the products of our space program are today's cathedrals. The space program satisfies the desire to compete, but in a safe and productive manner, rather than in a harmful one. It speaks abundantly to our sense of human curiosity, of wonder and awe at the unknown. Who can watch people assembling the greatest engineering project in the history of mankind—the International Space Station—and not wonder at the ability of people to conceive and to execute the project? And it also addresses our need for leaving something for future generations.

Of course the space program also addresses the acceptable reasons, and in the end this is imperative. Societies will not succeed in the long run if they place their resources and their efforts in enterprises that, for whatever reason, don't provide concrete value. But I believe that projects done for the real reasons that motivate humans also serve the acceptable reasons. In that sense, the value of space exploration really is in its spinoffs, as many have argued. But it's not in spinoffs like Teflon and Tang and Velcro, as the public is so often told—and which in fact did not come from the space program. And it's not in spinoffs in the form of better heart monitors or cheaper prices for liquid oxygen for hospitals, although the space program's huge demand for liquid oxygen spurred fundamental improvements in the production and handling of this volatile substance. The real spinoffs are, just as they were for cathedral builders, more fundamental.

Anyone who wants to build spacecraft, who wants to be a subcontractor, or who even wants to supply bolts and screws to the space industry must work to a higher level of precision than human beings had to do before the space industry came along. And that standard has influenced our entire industrial base, and therefore our economy.

As for national security, what is the value to the United States of being involved in enterprises which lift up human hearts everywhere? What is the value to the United States of being a leader in such efforts, in projects in which every technologically capable nation wants to take part? The greatest strategy for national security, more effective than having better guns and bombs than everyone else, is being a nation that does the kinds of things that make others want to do them with us.

What do you have to do, how do you have to behave, to do space projects? You have to value hard work. You have to live by excellence, or die from the lack of it. You have to understand and practice both leadership and followership. You have to build partnerships; leaders need partners and allies, as well as followers.

You have to accept the challenge of the unknown, knowing that you might fail, and to do so not without fear but with mastery of fear and a determination to go anyway. You have to defer gratification because we work on things that not all of us will live to see—and we know it.

We now believe that 95 percent of the universe consists of dark energy or dark matter, terms for things that we as yet know nothing about. Is it even conceivable that one day we won't learn to harness them? As cavemen learned to harness fire, as people two centuries ago learned to harness electricity, we will learn to harness these new things. It was just a few years ago that we confirmed the existence of dark matter, and we would not have done so without the space program. What is the value of knowledge like that? I cannot begin to guess. A thousand years from now there will be human beings who don't have to guess; they will know, and they will know we gave this to them.

LEFT TO RIGHT: NASM (SI NEG. #A-3759); NASM (SI NEG. #83-302); NASA (4)

SPACE AGE 50 FIFTY YEARS

5

After Sputnik was launched, space became fashionable.

THE LAUNCH OF SPUTNIK BLAZED AN ORBITAL TRAIL FOR HUNDREDS OF COMMUNICATIONS, REMOTE SENSING, WEATHER, AND SPY SATELLITES. FIFTY YEARS LATER, THE LITTLE SPHERE'S IMPACT ON SCIENCE, POLITICS, AND CULTURE IS STILL EVIDENT AROUND THE WORLD. THIS LIST OF ACTIVITIES SHOULD HELP YOU PREPARE FOR SPUTNIK'S HALF-CENTURY ANNIVERSARY THIS OCTOBER.

FIND OUT MORE

www.airspacemag.com

NATIONAL AIR AND SPACE MUSEUM CURATOR Roger Launius, author of more than 20 books on space exploration, reflects on the meaning of Sputnik and descibes how the events that Sputnik set in motion have influenced American culture. Read his essay on the *Air & Space* magazine Web site.

1 VISIT THE NATIONAL AIR AND SPACE MUSEUM in Washington, D.C., to see the Sputnik model (opposite, top) in the Milestones of Flight gallery, then tour an online collection of artifacts (*nasm.si.edu/research/dsh/artifacts*), ranging from a Sputnik music box to the slide rule used by Sergei P. Korolev, whose work established the Soviet school of rocket and spacecraft design. Or visit Moscow and walk the Avenue of the Cosmonauts toward mockups of Sputnik and a 300-foot titanium monument entitled "To the Conquerors of Space" at the Memorial Museum of Cosmonautics.

2 BECOME AN ASTRONAUT FOR A DAY at Space Camp, for campers age 7 to 18, at the U.S. Space & Rocket Center

PETER STACKPOLE / TIME LIFE PICTURES / GETTY IMAGES

6 Ways to Space Out

CELEBRATING 50 YEARS SINCE SPUTNIK

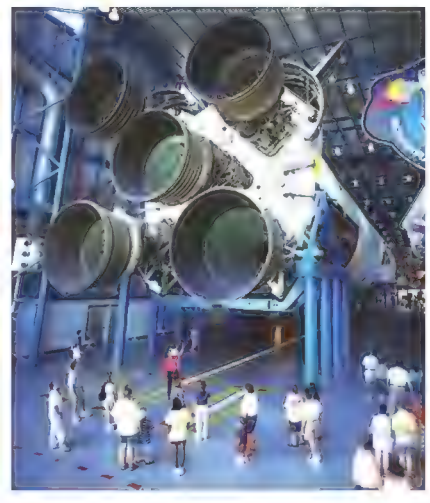
BY ROGER MOLA

in Huntsville, Alabama, *spacecamp.com*. For information, call (800) 63 SPACE. The Corporate Space Camp, also in Huntsville, is a leadership camp for adults (with all the fun space stuff you loved as a kid). Reach the Corporate Space Camp at (800) 894-2773 or online at *corporatecamp.com*.

YEAR IN SPACE.COM; NASA/KSC; SONY PICTURES

3 ▼ WITH A 2007 YEAR IN SPACE calendar, count the days until Sputnik's anniversary. Included are lists of this year's launches and space missions. Mention *Air & Space/Smithsonian* for a 25 percent discount on the $15.95 retail price when ordering online at *yearinspace.com/images.htm* or by phone: (800) 736-6836.

4 ▶ SEE SATURN V launch vehicles. The 363-foot, three-stage monsters, the last of which flew on May 14, 1973, are laid out at Johnson Space Center in Houston, Texas, Kennedy Space Center in Cape Canaveral, Florida, and the U.S. Space and Rocket Center in Huntsville, Alabama. The Huntsville display is actually a Dynamic Test Vehicle, never meant to go to space, but in 1987 the National Park Service designated it a historic landmark. For details on all



three, see *history.msfc.nasa.gov/saturn_apollo/display.html*.

5 TACK UP SPACE-THEME CARTOONS from *grinningplanet.com*, science fiction cartoons and parody from *cartoons.sev.com.au/Sev-Space/*, alien cartoons from *offthemark.com/aliens/aliens.htm*, and space politics and biting caricatures on *cartoonstock.com/newscartoons/directory/s/space.asp*. At *kidsastronomy.com/jokes/jokes.htm* and *exploreuniverse.com/spacejokes.html*, laugh at galactically lame jokes (How do we know Saturn was married more than once? He has lots of rings.)

6 ▶ WATCH *MUPPETS FROM SPACE* and understand why Sony Pictures' promotional team wrote the tagline "Space. It's not as deep as you think." You can buy the 88-minute DVD online for $9.95 from *amazon.com* or *muppets.go.com*.

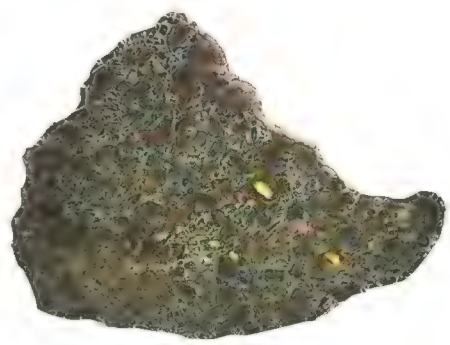
CELEBRATING 50 YEARS SINCE SPUTNIK

7 RENT A MOONSUIT from Moon Space Suits, which has supplied museums, filmmakers, and the producers of that Little Caesar's Pizza commercial. Find your personal moon suit at *moonspacesuits.com* or *spacesuit.net*, or (914) 481-4200.

8 CHALLENGE MYTHS about space travel, or invent some of your own, by downloading Jim Gerard's presentation, We Really Did Land on the Moon: Urban Legends of the Space Age, available at: *aesp.nasa.okstate.edu/georgia/ApolloUrbanLegends.ppt*. Send questions and comments to Gerard at *afgas1@gmail.com* for posting on his online forum.

9 ▼ STAR TREK FANS, there's more than one way to celebrate Sputnik's birthday. Pose with these *Star Trek Enterprise* wax figures when they tour a Trekkie convention in your galaxy. Chris Liebl and Lori Greenthal snatched them up at an auction for $34,000 in March 2006. "The Crew," from the former Movieland Wax Museum, is traveling while the partners raise funds for a permanent home. See *enterprisewax.com* for tour dates.

10 ENJOY THE MUSIC, dialog, and odd sound bites chosen to wake up astronauts from Gemini to the International Space Station. The playlist includes classic rock, country, jazz, international folk songs, children's chorus, television themes, and commercial jingles. Download the 62-page list, which reveals the personalities and anecdotes behind the selections, at *history. nasa.gov/wakeup%20calls.pdf*.



11 ▲ METEOR MUSEUMS exhibit what space is tossing back at us after 50 years of exploration. Read up on the subject in the online Meteorite Times at *meteorite-times.com*, and follow links to the International Meteorite Collectors Association. Visit the Institute of Meteoritics Museum, with its 1,600-pound Navajo iron specimen, at the University of New Mexico at Albuquerque, (505) 277-1644; the Oscar Monnig Meteorite Gallery at Texas Christian University in Fort Worth, *monnigmuseum.tcu.edu*; or the private R.A. Langheinrich Museum of Meteorites in Ilion, New York, (315) 894-0513 or *nyrockman.com*.

12 ATTEND A SPACE SCHOLARS PROGRAM at the Air Force Research Laboratory. To become a Space Scholar, you must be pursuing an undergraduate, master's, or doctoral degree in science or engineering. Get your application at *vs.afrl.af.mil/SpaceScholars/ index.aspx*. New this year are courses in Nano Space Weather Sensors, as well as Snap-Fit Composites (fabricating space structures by hand or by robot).

13 WITH ROCKET STATIONERY, send a friend a card printed on the "Astronaut Invitation and Thank You" set from Countdown Creations. A box of 10 six- by-nine-inch cards costs $12.95. Choose from dozens of space-theme party supplies, favors, space candies, snacks, and silly space hats. Shop for party favors online at *countdowncreations.com* or call (800) 388-3079.

14 LEARN TO SPEAK KLINGON with a free download for your Palm: the Mini Klingon Alphabet, from *freewarepalm.com*. Flip through the paperback Klingon Dictionary for $12.95 from Simon & Schuster, or read *The Klingon Way: A Warrior's Guide*, available from *amazon.com*.

15 50 YEARS OF SPACE HARDWARE are documented in 320 full color pages in *Space 50* by Piers Bizony. Learn about rocket exploration—past, present and future; pick up a copy for $40 from HarperCollins; *harpercollins.com*.

16 ▲ DISCOVER THE DESIGNS of Hermann Potocnik, pseudonym Hermann Noordung, a Slovene rocket engineer whose 1920s sketches were adapted for NASA's earliest space station designs as well as the fictional space habitat in the film *2001: A Space Odyssey*. Potocnik's milestone work, *Das Problem der Befahrung des Weltraums* (The Problem of Space Travel: The Rocket Motor), and his exquisitely detailed drawings can be viewed at *noordung.info*.

17 ▼ EXPLORE GRIFFITH OBSERVATORY in Hollywood, California. It was reopened with a newly renovated interior on November 3, 2006, after its first makeover since 1935. Some $93 million bought 60 new exhibits and 40,000 square feet, a 200-seat theater and 300-seat immersive planetarium with digital lasers and sound, and new polish on the plaque given by 1955 visitor James Dean (much of his movie *Rebel Without a Cause* was filmed at Griffith). Because the observatory expects a crush of

CHRIS LIEBL; INSTITUTE OF METEORITICS MUSEUM; GRIFFITH OBSERVATORY; NOORDUNG.INFO

visitors, it has set up a timed-entry program; make reservations for the parking-lot shuttle bus at (888) 695-0888 or *griffithobservatory.org*.

18 **SEND YOUR OPINION** into oblivion, or maybe on to unknown life-forms, via Blog in Space at *bloginspace.com*. Certify your age as 13 or older, and your ruminations (up to 2,500 characters) will be fed, at no charge, to a deep-space transmission dish. If you've got nothing to say, just buy Blog in Space boxers for $12.99.

19 **COLLECT ROCKETRY STAMPS** designed to honor such space travel achievements as the Mercury program, the first Chinese manned mission, and Earth-bound experiments in rocket mail. Visit *spacestamps.com* and *spacecovers.com* (for an international overview), *asss.utvinternet.com/index.htm* (the British Astro Space Stamp Society), and *philatel2.com*; click on "Postal History" for rocket mail.

20 ▼ **GRAB THE SPUTNIK 3 LAPTOP BAG** from Chrome, arguably the most tenuous promotional reference to the satellite in 50 years. Chrome says its collection "continues the pioneering spirit of the Space Age by launching Sputnik 3 into the vast cosmos of dull black laptop bags." The $75 bag, large enough to tote Laika (the first dog in space), has a metallic vinyl shell, nylon liner, and cell phone pouch. Call (415) 503-1221, or order at *chromebags.com*.

21 **STUDY SPACE LAW** at the Institute of Air and Space Law at McGill University in Montreal, established the same year Sputnik was

launched. McGill coordinates with the nearby Canadian Space Agency, the International Civil Aviation Organization, and the International Air Transport Association, and also publishes the *Annales de Droit Aérien et Spatial* (Annals of Air and Space Law). File your briefs at *mcgill.ca/iasl/*.

22 ▲ **SPACEWOMEN ARE HONORED** at the International Women's Air & Space Museum at Burke Lakefront Airport in Cleveland, Ohio. Honorees include the 13 First Lady Astronaut Trainees (FLATS, assembled by NASA in 1961) along with a roster of spacewomen from Valentina Tereshkova of the Soviet Union (1963) to Sally Ride, the first American woman in space (1983). The IWASM also helps Girl Scouts earn an Aerospace badge. Start online at *iwasm.org*, or call (216) 623-1111.

23 ▶ **SIMULATE DEEP SPACE** charting and travel by downloading two of the most detailed and realistic simulations, Celestia and Orbiter, for free. Celestia runs on Windows, Linux, and Mac OS X and gives your mouse freedom to hop around 100,000 stars in three dimensions: *shatters.net/celestia/* or *learn.arc.nasa.gov/planets/index.html*. Orbiter empowers you to plan entire missions, from launching the shuttle to designing hardware; *orbit.medphys.ucl.ac.uk/orbit.html*.

24 **HEAR THE ROAR OF A SPACE SHUTTLE ENGINE,** up close, at the Stennis Space Center in southern Mississippi. The StenniSphere Visitor's Center is free and open to the public Wednesday through Saturday (excluding holidays). You're invited to watch test firings of a space shuttle main engine either during regular hours or at scheduled test-fire viewings. Call (800) 237-1821 or check out *www1.ssc.nasa.gov/public/visitors* for more information. If you can't make the trip to Mississippi, watch a test firing at *http://www.nasa.gov/centers/stennis/home/index.html*.

25 ▲ **LET THE LEGO FORCE** be with you with the new Star Wars II: The Original Trilogy, from $19.98 to $39.99, depending on your choice of eight video game platforms. Available at *lucasarts.com* or *lego.com/starwars*, or call (800) 453-4652. Since 1978 more than 200 space-theme LEGO products have been created, like the Imperial Star Destroyer, Ultimate Collector version, with 3,104 pieces for $299.99, available at *shop.lego.com*.

26 **PLAY STELLAR MONOPOLY** with the U.S. Space Program edition, Night Sky edition, Astronomy edition, and Star Wars Original Trilogy edition (with collectible game pieces). You'll find most available online for $39.99 or less from *boardgamegeek.com* or *thespaceshop.com*.

27 **TOUR CAPE CANAVERAL** and check out Launch Complex 26, site of the first successful launch of a U.S. satellite, Explorer 1, in 1958, followed by the launches of the first three primates, Gordo, Able, and Miss Baker. The Air Force Space and Missile Museum at Florida's Cape Canaveral Air Force Station is open every day. Take the two-and-a-half-hour "Cape Canaveral: Then and Now" tour by bus from the Kennedy Space Center Visitor Complex. Reserve your seat by calling (321) 449-4400, or by going online at *kennedyspacecenter.com/visitKSC/NASAtours/thenNow.asp*.

CHROMEBAGS.COM; IWASM.ORG; NASA AMES; LEGO

CELEBRATING 50 YEARS SINCE SPUTNIK

28 SNAG A FREE POSTER from NASA's Kennedy Space Center Propellants, Pressure Systems and Life Support Office, with its flaming motto "You Can't Leave Earth Without Us." The office ships 24 types of liquid propellants, pressurants, and fluids in 200 tankers and tube trailers to support the space shuttle and Atlas and Delta rockets. Download a printable version at *propellants.ksc.nasa.gov/poster.htm.*

29 ▲ SPACE DOG is one of the classically styled windup toys sold by Tin Man Tin Toys. It sparks, flaps its ears, and opens its mouth ($19.99). Also available at *tinmantoys.com*: Zorgon, a foot-long rocket from the movie *Zathura* ($20.99) and dozens more.

30 STREAM HISTORIC SPACE FILMS from the National Archives to your desktop for free, courtesy of Google Video: *video.google.com/nara.html.* The 19 "Headquarters Films" are representative of 250 titles collected by NASA's Office of Public Affairs to represent then-state-of-the-art animation and imagery, such as the 1975 classic *Who's Out There?*, narrated by Orson Welles, and 1962's *The John Glenn Story.* Or check out the Johnson Space Center's compilation of 40 titles at Space Movies Cinema, *jsc.nasa.gov/er/seh/movies.html*, with titles from *Mooncar Motoring* to *Woodpecker Attack on Shuttle.*

31 VISIT MARS (or its beta test site, which compares Earth and Mars atmospheres) on the AtmosModeler Simulator at the Glenn Research Center, *grc.nasa.gov/WWW/K-12/airplane/atmosi.html.* Calculate how Mars' atmosphere would affect aerodynamics by inputting variables into the site's calculator.

32 ▼ SEARCH NASA'S IMAGE EXCHANGE at *nix.nasa.gov* for any image, moving or still, from the past 50 years of space exploration, including the one below, of the Spirit Mars rover's landing site. Go to NASA's gallery of human spaceflight to look up audio or images from shuttle missions, International Space Station missions, and others at *spaceflight.nasa.gov/gallery/.*

Or check out Dryden Flight Research Center's database of photographs, movies, and graphics at *dfrc.nasa.gov/Gallery.*

33 HEAR PATTI LABELLE sing "Way Up There" through the downloadable audio and video file at *nasa.gov/vision/space/features/labelle_grammy.html.* The NASA-commissioned anthem, for which LaBelle got a Grammy nomination, was written by Tena R. Clark for the seven astronauts who died in the space shuttle *Columbia* and was performed at the Washington, D.C. National Cathedral and at opening day 2003 for the Houston Astros.

34 LEARN THE ORIGINS of phrases like "It's not rocket science." A dozen language forums spar about that expression and many others at Web sites like *answers.com*; Language Log, *itre.cis.upenn.edu*; Phrase Finder, *phrases.org.uk*; and the Online Etymology Dictionary, *etymonline.com.* The latter traces the term "space cadet" to the 1950s TV program "Tom Corbett, Space Cadet."

35 TASTE ASTRONAUT FOOD developed by Pillsbury, shaped and textured to squeeze through a port on an astronaut's helmet. Pillsbury later added flavors and spun the products off commercially, but the fad faded after the 1970s space station *Skylab* was decommissioned. Last fall, the

Space Food Sticks Preservation Society revived the sticks in classic peanut butter or chocolate; the society sells them for $34.95 for a case of 24 sticks. Go to *spacefoodsticks.com.*

36 ▲ SALUTE NEIL at the Armstrong Air & Space Museum in Wapakoneta, Ohio—the first moonwalker's hometown. The museum presents not only Armstrong's story but all of Ohio's participation in spaceflight as well. Call (800) 860-0142 or go to *ohiohistory.org/places/armstron.* That's right; zero "G" in armstron.

37 READ SPACE POLITICS, the Space Age's version of the Drudge Report, because "sometimes the most important orbit is the Beltway." Visit *spacepolitics.com.*

38 JOIN THE CUBESAT PROJECT, an international collaboration among schools and private companies developing picosatellites (miniature satellites), which carry scientific, private, and government payloads. Build your own picosatellite with the CubeSat kit. Find plans at *cubesatkit.com/index.html*, or phone (415) 584-6360. Or build a simplified KatySat, tailored to students K through 12, using an affordable "Build a little, fly a little" approach, coordinated by a team from Lockheed Martin Space Systems; *katysat.org.*

39 BUILD YOUR OWN SATELLITE with the Satellite Construction Set from the Tech Museum of Innova-

TIN MAN TIN TOYS; NASA (2)

tion, *thetech.org/exhibits/online/satellite*. Construct one of three kinds of satellites—direct and broadcast TV, remote sensing, or scientific research—then choose a power supply, communications set, mission payload, and thermal protection.

40 ▼ MEET GEORGE JETSON, Jane his wife—or at least one of the 500 limited-edition sets of figures depicting Hanna-Barbera's "The Jetsons"; eight to 11 inches tall, $1,295. Call Gallery Art in Aventura, Florida, at (305) 932-6166 or shop online for product G12051 at *onlinegalleryart.com* or *gallart.com*.

41 BID ON SPACE RELICS at *astro-auction.com*. The collection ranges from astronaut autographs to coins and medallions to items that allegedly have flown in space.

42 ▼ VISIT THE KANSAS COSMOSPHERE and Space Center's Hall of Space Museum and wander through an extensive collection of U.S. space artifacts. The Hall of Space Museum houses the largest collection of Russian space artifacts outside of Moscow. Surf *cosmo.org*; (800) 397-0330.

43 SAVE YOUR BOXTOPS. Space Series Premium Reproduction Cereal Boxes, ($499 for a set of eight), are digitally reproduced to show the details on the original cereal boxes and include mail-away offers for reproductions of 1950s toys, such as Pep Tom Corbett Space Goggles and Post Raisin Bran Captain Video figures. Ask for item 40159 from ToyTent Antique and Collectible Toys in Idaho, (208) 263-0142, or online at *toytent.com/TrueReplica/40159.html*.

44 TRACK SPACE DOODADS with the *Field Guide to American Spacecraft* by NASA's Jim Gerard, a comprehensive list of space artifacts and their last known whereabouts. Artifacts include an X-15 rocket plane, a Mercury capsule, and the privately developed *SpaceShipOne* manned launcher—at *aesp.nasa. okstate.edu/fieldguide/pages/aaindex/home1.html*.

45 SEE THE SPACE DEBRIS inventory compiled by the U.S. Air Force Space Command Space Control Squadron (*peterson.af.mil*), which has been tracking man-made objects circling the Earth since 1968. The inventory of known space debris has grown to 13,400 objects that have diameters greater than four inches. *Wikipedia.org* lists artificial objects left on the moon, beginning with the Soviets' unmanned Luna 2 probe, launched in 1959, and extending through SMART-1, launched in 2006. See *wikipedia.org/wiki/List_of_artificial_objects_on_the_Moon*.

46 ▼ READ A BOOK featuring stunning photos and essays on space milestones—*After Sputnik: 50 Years of the Space Age*, edited by National Air and Space Museum curator Martin Collins and published by HarperCollins, *harpercollins.com*; $35.

47 SEE MOONROCKS Of the 842 pounds (from 2,415 samples) returned by Apollo missions, a number of rocks are viewable at museums around the country. Most are stored in the Lunar Sample Building at the Johnson Space Center and at Brooks Air Force Base in San Antonio, but the public can see others at the Kansas Cosmosphere and Space Center, at the Kennedy Space Center, or at the National Air and Space Museum: *cosmo.org*, *nasa.gov/kennedy*, and *nasm.si.edu*, respectively.

48 ▶ JOIN IN A SPACE SPOOF and mourn the passing of Ivan Ivanovich, a Russian Orlan spacesuit stuffed with dirty clothes that was shoved out of the International Space Station on February 3, 2006. Ivan, a.k.a. Suitsat 1 and Mr. Smith, orbited the Earth once every 90 minutes and was supposed to transmit, "This is Suitsat-1, RS0RS," plus words in French, Japanese, Russian, German, and Spanish, which were to be picked up by ham operators with scanners tuned to 145.990 MHz. The transmissions were to end after two days, but operators continued to hear Ivan's call for two weeks. His orbit decayed in recent months, leaving him to burn up upon his September 7, 2006 reentry of Earth's atmosphere.

You can check out the former Mir Fan Club, now the ISS Fan Club, at *issfanclub.com*.

49 DOWNLOAD EARTH at *earth.google.com*. The program takes images obtained by a variety of satellites, then pastes them together to provide you with close-up images of streets and cities around the world.

50 CELEBRATE SPUTNIK. Make a phone call, program a trip on your car's navigation system, check the weather, even find overhead images of your house—none of these things would be possible without the many satellites orbiting Earth 50 years after little Sputnik led the way.

KANSAS COSMOSPHERE; HANNA-BARBERA; HARPER COLLINS; NASA

Resto

'Hawks Come Home | Curtis P-40K

THE GERMAN ARMY was advancing toward Moscow and the Soviets were desperate for armament by the time the United States extended the Lend-Lease program to the Soviet Union in September 1941. The Soviet air force had lost more than 5,000 airplanes since the first German strike three months before. The British and the Americans sent thousands of airplanes to help replace the Soviet losses, among them, hundreds of Curtiss P-40s.

Now, two of those airplanes have come home. And British aircraft historian Mark Sheppard has traced their service histories. A Curtiss P-40K Warhawk, serial number 42-10256, left the Curtiss factory on Genesee Street in Buffalo, New York, on November 1, 1942, traveling by land to Brooklyn. Two days later it was on a ship to Murmansk, on the north coast of the Soviet Union.

After running the gauntlet of German submarines and North Atlantic weather, it began flying in the early spring of 1943 from Murmashi, 62 miles south of Murmansk. There it joined P-40K no. 42-10083.

On September 29, 1943, both aircraft were involved in a battle with four Messerschmitt Bf 109 fighters from *Jadgeschwader* (Fighter Wing) JG 5, probably based in Norway or Finland. Neither side scored conclusive hits, but when the German fighters broke it off, Junior Lieutenant I.I. Mikajlov, flying 10256, and Junior Lieutenant N.I. Alekseev, flying 10083, were lost and low on fuel. Separately, they belly-landed on the vast northern plains of Russia.

NASM (SI NEG. #15194)

The Soviets flew American-made P-40Ks under a Lend-Lease program.

Then, for more than 50 years, the fighters sat there, slowly deteriorating from the forces of weather and vandalism.

At some point in the 1980s, a Soviet team recovered 10083 from the tundra. The airplane was in surprisingly good shape, and was patched together ("restored" is too strong a word) and exhibited at a Soviet museum in Monchegorsk, a small town in the Murmansk region. Jim Pearce, an Englishman who has brought many World War II airplanes out of Russia, found 10083 in the museum, negotiated its purchase, and took it to Britain. Pearce then sold it to an American, Tom Wilson of Georgia.

Serial number 10256 wasn't so fortunate. When American Ken Hake recovered it from the spot where it had slid to a halt in 1943, the airplane was a battered hulk. Craters at the site suggested it had been bombed—why or by whom nobody knows. The aft fuselage and tail were gone, but the cockpit, wings, and Allison V-1710 engine were still there. Hake, who runs companies in Tipton, Kansas, that manufacture steel buildings and farm equipment, not only made hundreds of new P-40 parts (he'd acquired the remains of several other P-40s), he also made the equipment to fabricate the parts. After 10 years, most of 10256's air-

COURTESY MARK SHEPPARD

Each of a pair of P-40Ks made its way from the cold Russian steppe (right) to the relatively warmer tundra of northern Minnesota, where Ron Fagen (below, at left) and Erik Hokuf brought them back to life. Below right: A P-40K gets its tires.

© XAVIER MEAL

COURTESY WARHAWKS, INC.

frame had been re-manufactured and restored.

In 2003, businessman Ron Fagen bought both airplanes and brought them home to Granite Falls, Minnesota, where he turned their restoration over to Erik Hokuf. Hokuf, who at 28 is young enough that his great-grandfather might have flown a P-40 when it was new, made himself an expert on the design, learning the intricacies of its systems and construction.

"I loved the challenge of finding the documents, manuals, and drawings that describe how an airplane was built," he says. "It's out there, but you have to look in the 'unobvious' places. I found a magazine called *Aero Digest* that was published from the 1930s to the '50s. It was aimed toward aircraft engineers and manufacturers. In it, I found useful information like photographs of P-40s on the production line, but even small things, like ads showing manufacturing equipment, can teach you something if you look closely enough."

Fagen and Hokuf agreed that the restoration should be as authentic as possible. Because of Hake's excellent work, 10256 required less attention, so Hokuf started on it. "There are several P-40s flying today that are really conglomerations," Hokuf says. "They look like a P-40, but major portions of them aren't built the way Curtiss built them."

The signature of the P-40 is the famous shark's mouth—the reason the paint scheme works so well is the big scoop under the engine, which houses the oil cooler and radiator. The scoops are almost impossible to find, for the simple reason that when a P-40 landed wheels-up, the scoop was the first thing to hit the ground. Somehow, Hake unearthed a brand-new one. The original engine was beyond hope, so Joe Yancey of Rialto, California, overhauled one purchased from Florida warbird collector and pilot Kermit Weeks.

Hokuf spent three years, full time, on the P-40, working almost entirely alone. "Just me and Sparky," he says, rubbing the ears of one of the few airport dogs privileged to pee on a P-40 tailwheel. On May 25, 2006, Fagen rolled out 10256 and started the engine.

Shortly thereafter, he flew it—its first flight in 63 years, and perhaps the first time the airplane had ever been in American skies. In August, the P-40, now painted in accurate wartime colors and bearing a tiger's head design from an Alaska squadron ("Getting the paint right was the toughest part of the project," Hokuf says), flew to the Experimental Aircraft Association's AirVenture fly-in in Oshkosh, Wisconsin. There it was exhibited for the first time.

At the end of the show, number 10256 flew home with the Grand Champion Warbird trophy in the baggage bay. The aircraft is hangared with the remains of number 10083, which Hokuf is slowly restoring to flying status. If Fagen and Hokuf have their way, airshow fans will see the two in formation once more, almost 70 years after their combat careers came to an end on a Russian steppe.

KEN SCOTT

FIND OUT MORE
www.airspacemag.com
YOUNG GUN: *AIR & SPACE* INTERVIEWS P-40 RESTORER ERIK HOKUF.

"Authentic" is Hokuf's mantra, evident in the re-creation of the cockpit (below) as well as his selection of paint color and insignia (right).

© XAVIER MEAL (2)

IN THRUST WE TRUST

TO TIM PICKENS, ROCKETS ARE THE ONLY WAY TO GO.

BY PETER GARRISON
PHOTOGRAPHS BY CHAD SLATTERY

IT PROBABLY NEVER OCCURRED to Wernher von Braun that salami could be a rocket fuel. But it occurred to Tim Pickens. "We used a drill bit to bore a hole in the center, and lit it with a Fourth of July sparkler," he recalls. The aroma reminded Pickens of being at the state fair, and he fed what was left of the fuel to his cat.

For a guy who plays a leading role in the push toward commercial access to space, Tim Pickens has garnered a lot of publicity for goofy stunts. There was the rocket canoe, actually a Pickens-assisted project of Tim's friend Glen May, who produced 70 pounds of thrust using two small engines and rolled-up notebook paper for fuel. The canoe would hiss along at 20 knots or so, trailing a plume of dirty purple smoke, for as long as the fuel held up—not long enough to get May into trouble, or even to the middle of a small lake.

More fraught with peril was the rocket backpack Pickens built, then sold to an adventurous airline pilot before getting to fly it himself. During one tethered test the throttle got stuck and the contraption tossed the poor pilot around like a rodeo rider. Miraculously, he was not hurt. Pickens is still tinkering with that design.

There's the rocket pickup truck, a cobalt-blue Chevy SS with a rocket engine bolted to the bed and "In Thrust We Trust" emblazoned on the bumper.

Then of course there's the rocket bicycle. *Popular Mechanics* magazine awarded it a Breakthrough Award in 2005, triggering a flurry of copycat press coverage. Pickens and his daughter Sarah, for whom he had originally built a "cold" carbon-dioxide-powered rocket bike when she was 10, found their way onto Comedy Central's "The Daily Show." It was hard to tell from the interview, during which Jason Jones suggested that a rocket

bicycle would be a great way to get around on Mars, whether the deadpan Pickens was in on the joke or the butt of it.

To Pickens himself, the silly stunts have a serious purpose. "It's not about trying to break the land speed record," he says. "It's just going 20 or 30 mph down the road and feeling that acceleration and saying 'Wow, this is cool!' If you can't do something real once in a while, you're just running tests and looking at data, and it's way over there and it's 500 feet away. You could be an expert and never fly, and say, 'I'll tell *you* how to do it.' I want to *do* stuff, make it happen."

Pickens' gift as an engineer is, in fact, exactly that: making it happen, often in ingeniously simple and primitive ways. People already know how to get to space. "We've got all this data, we've got all this knowledge, but we still don't have a commercially viable, affordable launch system," he laments. "Right now it could cost from 15 to 20 thousand dollars a pound to get something into orbit. Affordable would be a quarter of that." His goal is to bridge that gap.

PICKENS WAS BORN in the rocket town of Huntsville, Alabama, in 1964, the last of six children. His father was, like him, a talented technician who had naturally drifted into engineering. While working on a degree in physics he taught ground support and electronics at the Army's Redstone Arsenal in Huntsville. Later he worked for NASA on the inertial navigation system for the Saturn V moon rocket. Except for what he calls four "dark years" during which the family moved to his mother's hometown, Jackson, Tennessee—compared to Huntsville, a technological wasteland—Tim grew up in the shadow of NASA's Marshall Space Flight Center, among the engineers and scientists who were sending larger and larger payloads farther and farther into space. But he was by inclination a hobbyist, not a professional engineer. When he earned a college degree, it was not in physics but in business.

His secret love was rockets, however, and he read about them compulsively, sucking in knowledge from far and wide, whether it was *Rocket Propulsion Elements* by Sutton and Biblarz or articles in popular magazines. Personal passion sometimes enables a spellbound amateur to surpass a bored professional. Pickens was mixing black powder before he was 10, and had designed and built a rocket motor at 12. By the time he was 16 he already counted a hang glider, a hovercraft, and an airboat among his engineering accomplishments.

In 1994 Pickens became involved in the efforts of HAL5—the Huntsville chapter of the grassroots National Space Society—to build the first privately funded rocket to reach an altitude of 50 miles. He learned about the project at a chapter meeting. "They were talking about putting a roach, or whatever they could, in space, and they had a little money. They had like $10,000," Pickens recalls. "I thought, 'This is really cool!' " He approached the program's director, Greg Allison, an engineer who had worked for several NASA contractors. Allison quickly recognized "innate capability" in the shy, 30-year-old Pickens, who at the time worked for an equipment rental company. He was a master machinist and a resourceful scrounger

Rocket motor in hand (inside a vacuum chamber), Tim Pickens wants to sell power to a new breed of space company.

Pickens fires up a "suitcase" hybrid rocket motor – fueled by plexiglass and nitrous oxide – that he sometimes takes along for demonstrations in schools. The motor runs for 20 seconds and provides up to five pounds of thrust.

who "could look in a garbage can and come up with a rocket," says Allison. The practical-minded Pickens was a breath of fresh air in a field where, Allison says, "there are a lot of people who are really good at flying viewgraphs and PowerPoint presentations."

HAL5 was largely populated with technical types who longed to escape the stultifying rocket bureaucracy: engineers who wanted to make a difference, idealistic engineering students eager to take what they were learning in school and apply it in the real world. Few of them, however, had Pickens' special combination of theoretical knowledge and mechanical experience.

It was Pickens who proposed using hybrid rather than solid rocket motors (see "The Right Fuel for the Right Rocket," p. 62), meaning that the engine would combine liquid and solid propellants. And he suggested using as a fuel asphalt rather than the conventional—but much more expensive and harder to handle—hydroxyl-terminated polybutadiene, or HTPB. The asphalt idea wasn't new with Pickens; he had gotten it from reading about an eccentric rocket pioneer named Jack Parsons, an early principal at NASA's Jet Propulsion Laboratory in Pasadena, California, who practiced black magic in his spare time. Eventually Parsons blew himself up while conducting backyard experiments, but not before he had demonstrated that ordinary paving asphalt was a pretty good rocket fuel.

Working on HAL5's HALO project, an acronym for high-altitude lift-off, Pickens recalls, "I knew that asphalt has a real low heat of vaporization, which means that you can easily heat it a little and get an ignitable vapor. You can pour it, you can cast it, and it's $17 for 100 pounds. Everybody laughed. I said, 'Okay, let's just test it.' Turned out it had as good a performance as the HTPB. But with the HTPB you had to mix the hardener, you had to do vacuum casting—it was just a pain in the rear."

Against advice from professional engineers, project director Allison decided to go the hybrid route for the HALO vehicle. "So we were going to use asphalt and laughing gas," Pickens relates. "We said, 'We're going to pave the way to space, and we're going to laugh all the way.' "

Pickens, who ended up in charge of HALO's propulsion system, assembled the motor from inexpensive components. For the oxidizer tank, he joined two donated aluminum fire extinguisher bottles, neck to neck. Drilling and tapping a hole in the bottom of one tank, he screwed directly into it the motor assembly: a cylinder of hand-wound graphite-epoxy with the fuel "grain" cast inside and the control valve and injectors at one end. The recovery parachute nestled in the depression between the two oxidizer tanks. Avionics and cameras perched on the nose of the rocket, under a conical cap. The rocket, enclosed in a wooden trusswork gondola, was to be carried to 100,000 feet beneath a helium-filled balloon. On firing, it would shoot up through the balloon on its way to space. The launching system—called a rockoon—was an old one that had been used for scientific sounding rockets in the early 1950s. Pickens nicknamed the team the "rockoon buffoons."

He built test stands and associated equipment, and would eventually log more than 300 static firings of the HALO motor. In March 1997, the group launched its rockoon from a beach in North Carolina. Unfortunately, the balloon split open before reaching its peak altitude, and the rocket, hastily fired from a vertical position as it fell, attained an altitude later calculated to have been 36 miles. As often happens with rocket development, the failure had its up side. The HALO rockoon reached the highest altitude ever for an amateur-built rocket, earning it an entry in the *Guinness Book of Records*.

A year earlier, Allison and Pickens had founded the High Altitude Research Corporation, and one of its early projects was to go after the CATS (Cheap Access To Space) prize, offered by the Space Frontier Foundation for the first amateur-built rocket to lift a two-kilogram (4.5-pound) payload to an altitude of 200 kilometers (124 miles). The team's entry—"HALO on steroids," Allison calls it—blew itself apart 100,000 feet over the Gulf of Mexico in 2000, only days before the $250,000 CATS prize expired unclaimed.

It wasn't long, though, before Pickens had another project to work on, for even higher stakes.

IN 1999, BURT RUTAN, who had launched his aeronautical engineering career 25 years earlier with an arresting series of canard designs for amateur airplane builders, came to Huntsville to speak to a chapter of the Experimental Aircraft Association. The visit had an ulterior motive; Rutan was scouting companies involved in rocket propulsion because he wanted to compete for the X Prize, a $10 million award awaiting anyone who could launch a reusable passenger vehicle into space twice within two weeks.

"You know, I'm getting bored with flying," Pickens recalls Rutan announcing to the homebuilders (which must have been like Jesus saying to the apostles, "I'm getting tired of religion").

"I'm really thinking about rocket-

ships," Rutan said. "I've looked at solid [fuel]s, I've looked at liquids, I'm looking at all options. If there are any rocket people out there who can steer me...." Rutan had been talking to the big players in industry—Aerojet and Thiokol—and both had offered existing engines. They even offered to send out guys in spacesuits to fuel it. "Spacesuits?" Rutan said. "We're not even going to have spacesuits inside the ship!"

After the meeting, Pickens introduced himself. "I'm really concerned," he said. "If you go to the big guys, you're gonna lose your shirt. And you ain't never gonna come out of the woods."

They talked at length, and Rutan, himself a maverick engineering prodigy, discerned in Pickens the same capability that had struck Greg Allison. Pickens convinced Rutan that he could make the X Prize motor happen. Returning to his company, Scaled Composites, in Mojave, California, Rutan gathered his team in a conference room for a working lunch and announced, "I've found the guy who's going to put us in space." He then played a video of the rocket bike and the rocket canoe. One Scaled engineer remembers the incredulous reaction. " 'Burt,' everybody says, 'you have lost your mind!' "

At that point it was still not a foregone conclusion that the engine for Rutan's spaceship would be a hybrid. For a year the e-mails flew back and forth between him and Pickens, who was still only an unpaid advisor. In 2001 Rutan, having pared an initial list of 21 possible rocket engine suppliers down to six or seven, visited Space America, a now-defunct Huntsville-based company for which Pickens was then working. Space America intended to build a launch system for putting small payloads into orbit and had built a 12,000-pound-thrust regeneratively cooled liquid-fuel engine. But something unexpected happened during the presentation for Rutan. The wrong video somehow found its way into the VCR, and rather than a successful test firing Rutan was treated to the dramatic spectacle of the liquid engine blowing itself to smithereens. "Whoa!" Rutan exclaimed. "There went my crew."

COURTESY TIM PICKENS

Burt Rutan (right) with Pickens at *SpaceShipOne*'s rollout in April 2003. The self-taught engineer was Rutan's "golden boy," recalls test pilot Mike Melvill.

"That hosed it for liquid [fuel]s," says Pickens, laughing.

Rutan, a fanatic for simple systems that use as few parts as possible, was looking for a "bolt-in" propulsion system like the manufactured engines he used on his airplanes. But he was finally won over by Pickens' arguments for hybrids, even though the choice meant designing an engine from scratch and making a new one for each flight. Rutan was willing to accept those penalties, along with the reduced performance of a hybrid motor, in exchange for tossing out all the tricky plumbing and valves and hassle that liquid oxygen required, not to mention reducing the risk of an explosion like the one he'd seen on the videotape.

According to Rutan, Scaled came up with the concept for *SpaceShipOne*'s motor and designed, built, and tested its main components, including a massive flange on the tank and motor case from which the motor was cantilevered. Scaled also built the nozzle and the carbon-wound fuel casing. Only a few internal components, including the injector, igniters, and motor controllers, were outsourced, because Scaled had no experience in those areas. Rutan got a couple of small companies, eAc of Miami and SpaceDev of San Diego, to build and test the subsystems. "We did not have full confidence that any small shop could do an adequate job with these components," he says, so Scaled

Orion's "Rocket Truck" started as a 2004 Chevrolet SS, then was tricked out with one of the company's HRM 2700 hybrid rocket motors. More than just a stunt, the truck allows the engineers to test their propulsion technology in what Pickens characterizes as "an aggressive environment."

Sarah Pickens' Sting-Ray, adorned with the words "Rocket Girl," is likely the only bike in town with a carbon dioxide propulsion system.

awarded two contracts, "hoping that at least one would work." Ultimately, *SpaceShipOne* included hardware from both SpaceDev and eAc on its historic test flights. (SpaceDev founder Jim Benson tells a different story, and is still arguing with Rutan over who should get credit for the vehicle's propulsion system.)

Pickens finally went to work for Scaled Composites in 2002, with the title Propulsion Lead Engineer, or, as he likes to put it, Herder of Cats. He remained at the Mojave headquarters for a year before returning to Huntsville and his wife Melanie and their daughter Sarah. "He chose his family over his career," Rutan says with a slightly disapproving tone. Pickens puts it differently. "A country boy from Huntsville, we just don't go off and chase too big of dreams. You gotta eat mama's cooking at night, you know what I mean?"

But Pickens' year designing the engine for *SpaceShipOne* at Mojave had been decisive for the project. He was, test pilot Mike Melvill recalls, Rutan's "golden boy." And his thinking permeated every detail of the engine. The common bulkhead between oxidizer tank and motor, which had been a basic design feature of the HALO and CATS rockets, became a key element of *SpaceShipOne*'s design, one that Rutan patented. Without Pickens, Melvill thinks, *SpaceShipOne* might not have worked.

A year after leaving Scaled, Pickens did something unexpected: Under the aegis of the corporation he had formed with Allison, he entered the X Prize race himself. He called his project Liberator. It was a conventional single-stage, liquid-fuel rocket, about two-thirds the size of the Huntsville-made Redstones that had lofted America's first satellites into orbit in 1958. "I'm sitting at home with a lot of rocket hardware—engines and tanks and valves and stuff," recalls Pickens. "I had one 12,000-pound-thrust regeneratively cooled kerosene-LOX [liquid oxygen] engine, and parts for another. And I'm thinking: I could do a mission like this."

The crew capsule was a tall metal tube in which the occupants sat one above the other. It was not for the claustrophobic, but the X Prize did not stipulate that the passengers be comfortable, nor that anyone but the pilot be on board for the test flights—just that the vehicle had to have enough room to seat three people.

It was very late in the game, but despite having worked at Scaled for a year—or perhaps because he had—Pickens had doubts about Rutan's vehicle. At the time its key technologies, especially the idea of folding the wings to increase drag during reentry, had not yet been tested at supersonic speed. To Pickens' knowledge, there had been no wind tunnel work; all of the aerodynamic analysis of the *SpaceShipOne* design had been done on a desktop computer, and for fun, the early flight simulations were run on X-Plane, a $70 home entertainment program for airplane buffs. "There were performance issues," Pickens recalls. "We figured *SpaceShipOne* would probably slide—who knows what

The Right Fuel for the Right Rocket

EVEN THOUGH THEY HAVE their downside, hybrid rocket engines combine the advantages of liquid and solid rockets. A liquid oxidizer, typically nitrous oxide or "laughing gas," is carried in a separate tank, from which it is injected down the center of a tubular "grain" of rubber fuel. Hybrids therefore have the simplicity of solid rockets, in which fuel and oxidizer are both present in the grain, and the controllability of liquid-fuel engines, which can be throttled, or even stopped and restarted, in flight.

They also can use any moldable hydrocarbon for fuel. Many hybrids run on tire rubber, and Tim Pickens often demonstrates the technology with small transparent motors made of plastic: The motor is its own fuel, and devours itself as it runs.

A critical parameter for any rocket propellant is its specific impulse, or Isp. An Isp of 250 means that one pound of the fuel, if burned at a rate sufficient to produce one pound of thrust, will burn for 250 seconds – or, if you prefer, it could produce 250 pounds of thrust for one second. Solid fuels have lower Isps than liquids do, and hybrids can be worse still, in the range of 200 to 210 (salami can get up to 180, says Pickens). But rocket fuels, like people, become more dangerous as they get more powerful. Really energetic fuels are toxic, difficult to store, and liable to self-ignite, while fuels that are safe and easy to handle, perversely, yield less thrust for a shorter time. So even with salami fuel and self-eating rockets, there's no free lunch.

At Orion's "East Test Site" – a remote location in Gurley, Alabama – Pickens fits a nose cone onto a full-scale mockup of the Liberator escape motor.

can happen, we can't worry about them, let's move forward."

Instead of Rutan's plan to drop his vehicle from another airplane, "I was banking on a traditional rocketry approach," says Pickens. "Ocean landing. I'd done ocean launches with the NASA barge program and also the HALO program. We definitely were in the right town with the right talent pool. In my opinion we were certainly one of the two or three most technically competent teams."

The showstopper turned out to be not technology but money. "Boy," laughs Pickens, "did I learn a lot about reality. Somebody might want to give you $10,000, but if he's only got $100,000 to start with he's gonna annoy you just as much as somebody who had 10 million dollars and gives you a million."

Orion Chief Engineer Steve Mustaikis with a self-devouring acrylic rocket motor.

Liberator didn't have time to turn into a full-fledged debacle, because Scaled won the Ansari X Prize in 2004. "In the last months they pulled a lot of rabbits out of their hats," says Pickens. But Rutan's former employee had learned a precious lesson. "I realized my business is not gonna be based on selling rides. I'm gonna sell shovels to the miners."

Selling shovels to the miners means doing what he's always done best: putting together practical rockets and related hardware such as test stands, using existing, robust, proven technologies. He set up a new company, Orion Propulsion, borrowing the name from his father, who had started a telecommunications test equipment business called Orion in 1982. Orion Propulsion has already become a small but steady player in a field where startups come and go at a dizzying rate. In its second year of business, the company had 11 employees and revenues of more than $2 million, and had landed several NASA contracts and subcontracts. If another big contract comes through this year, the company will add about 30 employees; Orion is on a Boeing-led team bidding to build the upper stage for NASA's new Ares 1 crew launcher. The company's most ambitious current project is Responder, a multi-stage rocket designed to put up small satellites—five kilograms or so—at low cost and on short notice. The project will be funded by Orion and a consortium of government partners.

Responder's engine is not a hybrid. "Orbital [space travel] is an order of magnitude harder than suborbital," Pickens observes, and that's where the difference in propulsion systems comes into play. Fuel efficiency is not critical for suborbital tourist vehicles like Rutan's; instead, reliability and safety are paramount. For the much more difficult task of lofting payloads to low Earth orbit, hybrid engines are significantly less efficient than the time-honored pairing of kerosene and liquid oxygen.

The project demands all of Pickens' ingenuity and everything he's learned in his dozen meteoric years in the rocket business. "You ask yourself: What can I do to support the industry without sticking my neck way out? And that's how we've come back to 'Well, we can do propulsion, do testing, and we can do ground support,' " he says. "Right now the company doesn't have any debts. We made a profit last year and this year. It's working. And I think it's really gonna work once NASA's budget is turned on. Because at the end of the day, somebody's gotta *build* 'em." And somehow, you know Tim Pickens will be right there among the somebodies.

How Things Work:

Afterbu

BY DAMOND BENNINGFIELD | ILLUSTRATION BY JOHN MACNEILL

WHEN A JET NEEDS AN EXTRA KICK TO LAUNCH FROM AN AIRCRAFT CARRIER, PUNCH PAST MACH 1, OR EVADE ENEMY WEAPONS, IT USES ITS AFTERBURNER.

Producing a big jolt of thrust—and dramatic flame—the afterburner is a simple design dating to World War II, when engineers in Germany, the United States, and elsewhere tinkered with ways to boost the thrust of underpowered jet engines without adding much weight.

Americans tested their first afterburning engine in 1943, and six decades later afterburners remain in use among the latest generation of U.S. warplanes, which can achieve supersonic cruise speeds without them but continue to rely on them for critical maneuvers.

A typical jet engine uses only about half the oxygen it ingests, leaving a large amount of potential energy. The afterburner, which is a long extension at the back of the engine, combines much of the remaining oxygen with jet fuel, squirted into the high-speed exhaust stream from the engine's turbine, and ignites the mixture. The resulting blowtorch shoots through a nozzle at the back of the engine, providing a hard kick of extra thrust.

The size of the boost varies. The afterburners on the Olympus engines that powered the Concorde supersonic jet added only about 17 percent to that engine's thrust.

For the engines that power modern fighters, the increase ranges from about 40 to 70 percent. One hallmark of an afterburning engine is inefficiency: Using it guzzles up to three times as much fuel, so pilots typically limit its use to a few minutes per mission.

Although the design of an afterburner is simple, it operates with extremely sensitive tolerances. Maintaining a stable flame is the first challenge, since ignition needs to occur within air racing from the engine's turbine into the afterburner at several hundred feet per second.

"It's like lighting a butane lighter when you're sticking it out the window of your car and holding it behind the side mirror," says Derk Philippona, an engineer with a fellowship at Pratt & Whitney, which produces several afterburner-equipped engines, including those for the U.S. Air Force's F-22A Raptor.

Fuel enters through a series of small tubes—typically 10 or so—that form a ring around the engine. The fuel sprays from hundreds of tiny holes in the tubes into the air stream, where it's ignited, usually by an electric sparking device.

"You need to insure that when you spray fuel into the high-velocity air stream, it doesn't just blow out the tailpipe," says Louis Povinelli, chief scientist for turbomachinery and propulsion systems at NASA's Glenn Research Center in Cleveland, Ohio. The ignition process is "still somewhat of a black art," he says.

The afterburner is designed so that the flame flows along its axis, away from its walls. Careful placement of the fuel tubes and the ignition source at the front end of the jetpipe (the four- to seven-foot-long tube at the back of the engine), where hot but not burning exhaust gas is flowing out of the engine, creates a stable zone in the airflow where air and fuel can mix.

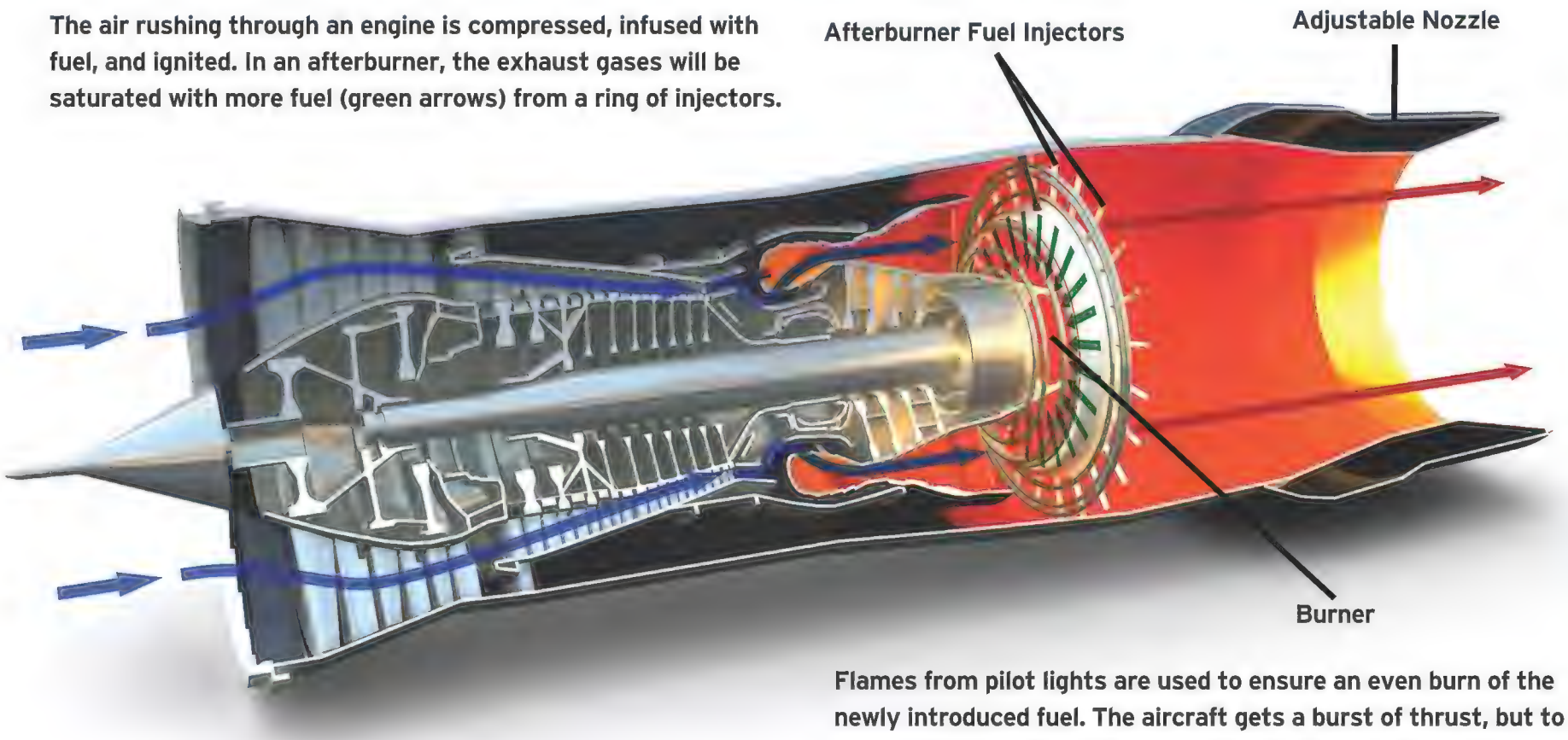
The stable flow ensures that the flame ignites quickly and burns at a consistent location. If the flame moves around, it

AIRMAN APPRENTICE NATHAN LAIRD, U.S. NAVY

An F/A-18 Hornet lights its afterburners to leap from the deck of the aircraft carrier USS *Theodore Roosevelt*.

rners

The air rushing through an engine is compressed, infused with fuel, and ignited. In an afterburner, the exhaust gases will be saturated with more fuel (green arrows) from a ring of injectors.



Flames from pilot lights are used to ensure an even burn of the newly introduced fuel. The aircraft gets a burst of thrust, but to prevent an increase in pressure, the exit nozzle must widen.

could set up oscillations that eventually could burn through the jetpipe or damage the end of the exhaust nozzle.

Designers often also add pilot lights downstream from the ignition spot to make sure that the flame burns evenly and consumes all of the fuel that flows into the afterburner.

Another challenge is keeping the metal jetpipe cool in the afterburner's high temperatures, which can reach 3,000 degrees Fahrenheit.

"People keep pushing the limit between the gas temperature and the melting point" of the engine components, says Povinelli. "The materials aren't any different than other parts of the engine, and the walls aren't especially thick."

Cold fuel flowing through tubes at the top of the afterburner absorbs some of the heat, Povinelli explains.

More recent turbofan engines add a flow of cold air through a ring around the barrel-shaped engine, bypassing its combustion chamber. At high altitudes the temperature is well below zero, and the influx of cold air into the afterburner pipe helps protect it against the flaming exhaust.

As the exhaust races out the back, the engine's nozzle is designed to open wider to accommodate the extra volume of hot gas, preventing any increase in pressure inside the engine.

One problem with this arrangement, engineers note, is that things that tend to be good for combustion are bad for stealth, and vice versa.

With afterburners, the open tailpipe welcomes enemy radar waves, which enter the hole and bounce back a strong signal even when the afterburner is not lit.

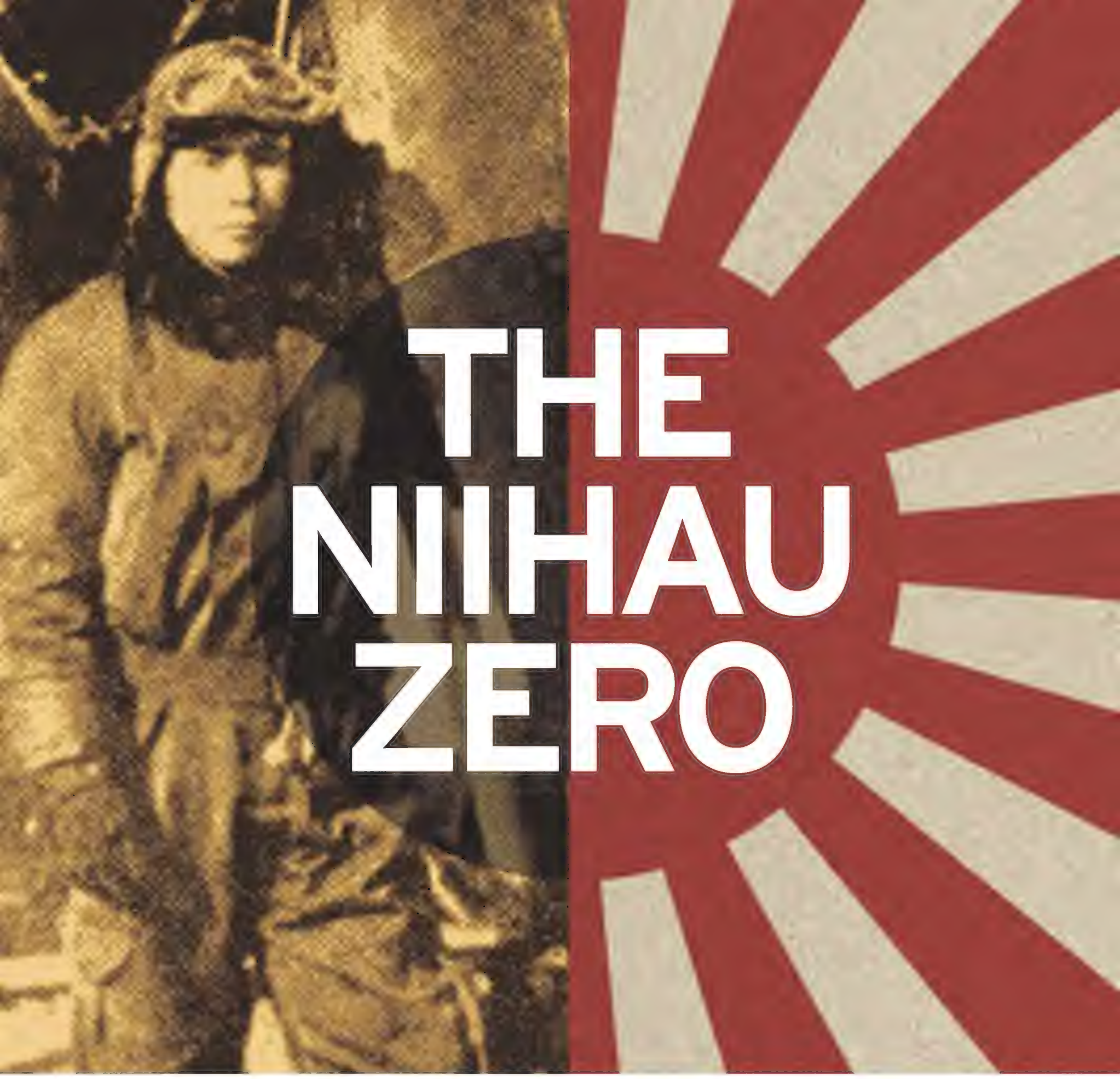
It is also nearly impossible to hide the infrared emissions from a lit afterburner and its nozzle—structures that stealth airplanes like the B-2 and F-117 don't have.

Using a turbofan, which mixes cool air with the turbine exhaust gases, helps decrease the signature a little.

Future designs, featuring afterburner nozzles built into the fuselage and cooled with bypass air, may mask the jetpipe's infrared emissions. Engineers also are evaluating construction materials that absorb heat, similar to space shuttle thermal tiles, and other engine designs that would create stealthier afterburners.

But there is no way to fully hide a plume of hot air roaring from the back of a warplane. The only way to preserve stealth is to reduce the reliance on afterburners. The F-22A, for example, can cruise at about 1.5 times the speed of sound without lighting the afterburner.

Still, aviation engineers say afterburners will remain in use well into the 21st century. Although carrier takeoffs are the most common of current uses of the afterburner, extra speed is always useful in combat. As long as military pilots might need extra bursts of power, afterburners are likely to remain the solution.



THE NIIHAU ZERO

PIECES OF PEARL HARBOR'S LONE SURVIVING MITSUBISHI A6M2 TELL OF A VIOLENT CLASH OF CULTURES AND A RACE FOR TECHNOLOGY. **BY NICK D'ALTO**

FLYING IN THE SECOND WAVE of the attack, he had vanquished the remaining aircraft intended to protect Pearl, a task so easy that his own return flight to the carrier should have proved uneventful. But now his Zero was leaking fuel badly, forcing him to make an emergency landing. The barren island below, called Niihau, was tiny and of no consequence compared with the world-changing events that had unfolded earlier that morning, December 7, 1941. Yet six days later, Airman First Class Shigenori Nishikaichi would be dead, killed by an islander, while another island resident who had helped the pilot would take his own life, all the result of a strange incident of invasion and resistance in the Pacific war.

"I never knew about this," visitors invariably tell education director Kathryn "KT" Budde-Jones as she guides them through the pieces of the ill-fated Zero on display at Ford Island's Pacific Aviation Museum—Pearl Harbor (see "Where the War Began," Aug./Sept. 2006). Amid the wide-eyed children scurrying past exhibits and the museum crowd murmuring on a bright afternoon, it does sound implausible: That a Japanese pilot returning from the attack on Pearl Harbor crash-landed his Zero on Niihau ("Nee-ee-how"), a remote island 18 miles west of Kauai; that he terrorized its native inhabitants,

threatening to kill them all; that his aircraft survives, though burned and in pieces, preserving the story of Mitsubishi A6M2 type 0, model 21, tail number B11-120.

Even KT and her husband, Syd Jones, the museum's director of restoration, did not know the tale. Both have had their share of adventure, from diving for Spanish galleons with treasure hunter Mel Fisher to piloting vintage aircraft at the Flying Tigers Warbird Museum in Florida, and both agree that the "Niihau Incident" is "befitting a Hollywood movie," says KT, relating how the wayward Zero tumbled to Earth, knocking its pilot unconscious. And how ranch hand Howell Kaleohano rushed outside to find a smoking aircraft in his front yard.

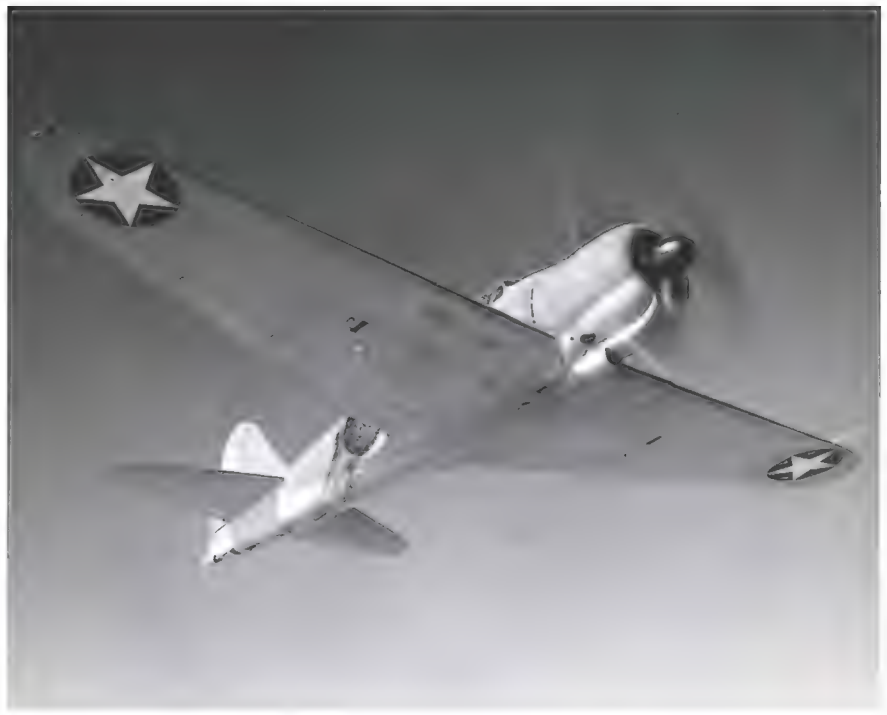
"He and his fellow islanders had no inkling Pearl Harbor was under siege," KT says (there were no telephones or electricity on Niihau). Nor could they understand the injured pilot (they spoke only Hawaiian). That night, as Pearl burned, the islanders treated their drop-in guest to a luau. Then the young Nishikaichi began demanding the return of his papers and weapons—items that the savvy Kaleohano had lifted on reaching the wreck.

"I played pilot in the wreck as a child, *rata-tat-tat!*" says Keith Robinson, who descends from the family of New Zealand farmers who bought Niihau from Hawaii's King Kamehameha IV in 1864. Robinson's uncle, Alymer Robinson, oversaw Niihau when the Zero crashed. Today, Keith's mission is to preserve the endangered species that inhabit the island, along with its Hawaiian language and culture.

In the museum's exhibit, B11-120 lies in fragments, arranged to correspond to how this *Rei Shiki Sentoki* (Type 0 Fighter) came to rest amid the boulders and abutilon weeds of Niihau just hours into the Pacific war. Syd Jones had heard stories about a crashed Zero on Niihau, but the trail went cold after U.S. inspection teams had disassembled it in 1941. He found a historian, Allan Lloyd, who reported that he had been to Niihau, had met the Robinsons, and had seen the wreckage. After grilling the Joneses on their motives, Lloyd put the pair in touch with Keith Robinson, who ultimately wanted only to get the real story of the Niihau Zero on the record.

"We treated it as an archeological site," Syd recalls of his 2006 trips to secluded Niihau, once called "the Forbidden Isle" and even today accessible only with permission from the Robinson family. "I wrote up pre-disturbance guidelines for us to follow. Very little info comes out of Niihau, so we really didn't even know where the aircraft was, relative to where it crashed, or what state it was in."

Syd's first challenge was reconstructing the crash itself. To do so, he flew Nishikaichi's 1941 approach to the island, some 150 miles northwest of Pearl Harbor. "We wanted to see if there was some



NASM (SI NEG. #A-47765-0)

Long before this November 1942 test flight of a U.S.-captured Zero, Allied pilots had learned to refrain from dogfighting with the nimble Japanese fighter.

OPPOSITE: COURTESY BARNUM FAMILY; BELOW: KT BUDDE-JONES-PACIFIC AVIATION MUSEUM

Sixty-five years after Airman First Class Shigenori Nishikaichi (opposite) crash-landed his A6M2 Zero on a tiny Hawaiian island, restorer Syd Jones lays out the surviving pieces.

COURTESY BARNUM FAMILY

A week after the "Battle of Niihau," Allied forces moved in to disassemble the Zero to learn what made it tick. The process was documented by Presbyterian minister Paul Denise, who gave his hundreds of photos to the U.S. Navy.

possible way of finding additional pieces of the wreck, [to] establish a primary scatter trail of artifacts as the aircraft bellied in," he says. Eyewitness testimony honed the search. "We interviewed a Niihauan who, as a young man, saw the plane come in. It turned out the aircraft was not where it originally crashed." Prior to recovery, the team went to Niihau, prepared a photo-mosaic of the wreck, and tagged the larger pieces for later identification.

Back to Oahu's Ford Island, to reconstruct the airplane and what actually happened. "We laid out the parts in a grid on the museum floor," Syd says, "to identify what part went where, in the proper relationship and spacing from each other. We were able to identify about 95 percent of the pieces we found. Fortunately, there was another A6M2 in our hangar we could refer to"—a Nakajima-built Zero recovered from the Solomon Islands, restored, and recently acquired from the Commemorative Air Force. "We had the drawings, but it's easier to go to the real thing."

The wing, portions of the tail, the elevator, and an aft section of its 950-horsepower Nakajima Sakae twin-row 14-cylinder engine survive. Zeros were light—about two-thirds the weight of a Supermarine Spitfire—though what remains seems sculpted from Reynolds Wrap. "Sitting outside in a salty environment for 60 years didn't do this plane any favors," Syd says. "Still, this is the largest surviving collection of artifacts from any [aircraft] shot down at Pearl."

As displayed today, the fragments record B11-120's three lives: invading aircraft, captured secret weapon, and forgotten wreck. It still has the mounting points for the two 20-mm cannon Nishikaichi used to lay waste to Hickam Field and Kaneohe Air Base. A piece of a drop tank remains—the pilot didn't jettison it before crashing. Was B11-120 out of fuel? Eyewitnesses told Keith Robinson the airplane glided in, engine dead. "A[n early] Zero's main tanks wouldn't self-seal after being hit," Syd notes. Perhaps something at Pearl—a ground gun?—found its mark.

There is burn damage across the main spar and beneath the cockpit, though not from the crash. "Japanese pilots had been ordered to emergency-ditch on Niihau to await a rescue sub," Syd explains. "But the sub rescue never came off. So the pilot set his plane on fire to keep its secrets from the Allies." Then, desperate to force the return of his papers, Nishikaichi began to terrorize the islanders.

Keith Robinson recalls the scene from Niihau lore—how the Kiawe trees shuddered as the pilot sprayed them with the Zero's 7.7-mm machine guns; the islanders fleeing into the jungle, lighting bonfires and shining flashlights to signal the neighboring islands. Howell Kaleohano man-

NASM (SI NEG. #7A33871)

More than 100 A6M2 Zeros (foreground; Val dive bombers behind) from six aircraft carriers raided Pearl Harbor. Only nine – including B11-120 – did not return. Land-based Zeros then escorted bombers to attacks on U.S. air bases in the Philippines.

KT BUDDE-JONES-PACIFIC AVIATION MUSEUM (2)

Jones (opposite, at left) shows field work to Niihau's Keith Robinson, who let the Pacific Aviation Museum display the Zero pieces.

aged to reach a whale boat. He rowed for 10 hours to Kauai, where Alymer Robinson—unable to reach Niihau because of an emergency Navy curfew—fretted over his island's fate. Another islander, Bene Kanahele, fought the Japanese pilot. In the last moments of the siege, he took three slugs from the pilot's pistol but kept coming, finally throwing Nishikaichi against a stone wall. Kanahele's wife, Ella, bashed the pilot's head with a rock, and Kanahele slashed his throat, killing him.

The frenzy of the Allied inspectors who rushed in days later to examine one of the "superplanes" that had just vanquished the U.S. Pacific fleet is apparent in the torn-up wreck. "My Uncle Alymer brought them over in sampans to find out what made this plane tick," Robinson recalls.

"The inspectors actually used hacksaws and axes," Syd says. He's found the tooling marks. "Anything removable came off. The landing gear is gone. They took almost every wire. All the hydraulic stuff." Why such haste? "There was fear of a second attack, and invasion, at any moment," Robinson says.

Fortunately, the Niihauans proved more careful curators. Gilbert K. Pahulehua Jr. is now chief elder on the island. "He saw us coming," Syd recalls, describing how Pahulehua emerged from his house carrying a piece of the Zero's engine that his father had preserved. Photographs survive thanks to another unlikely source—the Reverend Paul Denise, a clergyman on Kauai, who joined the mission to examine the wreck. As inspectors hacked up the airplane, the Presbyterian minister quietly snapped over 500 photos, compiling the Allies' first reliable dossier on Japan's most secret aircraft. "Of course the Navy took possession of those photos," recounts Craig Barnum, Denise's grandson.

"As soon as the inspection was finished," Syd says, "what was left was dragged about 300 yards [to] beneath a stand of trees, to conceal from Japanese reconnaissance that a plane had landed on the island and was captured." There B11-120's hulk remained, obscured but not entirely idle in the hands of the resourceful islanders. "They peeled off swatches of the aluminum wing skin," Robinson says. "Perfect for rolling into eyelets for their fishing nets." The Robinson family eventually agreed to loan the wreck to the museum.

For his valor, Howell Kaleohano was awarded a Medal of Freedom in 1946. Bene Kanahele received a Medal of Merit and a Purple Heart. Against stunning defeat at Pearl Harbor, their unlikely victory received national acclaim. The December 1942 issue of *Reader's Digest* regaled its audience with the exploits of the "full-blooded descendants of ancient Hawaiian warriors." A wry Hawaiian ditty entitled "They Couldn't Take Niihau, No-How," penned by musician Alex Anderson, became America's first World War II victory song.

One mystery remains unsolved: the tragedy surrounding Yoshio Harada. A Nisei (second-generation Japanese-American) living on the island, he spoke with the pilot, but did not reveal the attack on Pearl to the others. He then helped Nishikaichi terrorize the villagers before shooting himself when the siege ended. Whatever motivated Harada's alliance, others would pay dearly for it. "The incident was used to help justify the dislocation and internment of thousands of Japanese-Americans during the war," says KT Budde-Jones. "So many worlds collided when this plane crashed here."

Furrows Foil an Imperial Navy

THROUGHOUT WORLD WAR II, Cleveland Tractor earth-moving equipment was often used to remove aircraft mired in jungle bogs. But the Cletrac displayed beside the wrecked Zero at Hawaii's Pacific Aviation Museum served an opposite purpose, one that often spoiled Keith Robinson's boyhood fun. "I hated them – you couldn't travel across them," he says, recalling the endless patchwork of furrows that once crisscrossed the island of Niihau.

Recently the museum's director of restoration, Syd Jones, identified the U.S. Army Air Corps officer whose discreet pre-war visits to Niihau prompted the curious ruts. Lieutenant Colonel Gerald Brant was a protégé of General Billy Mitchell, whose doctrine of air power included a prediction that if captured, tiny Niihau, the westernmost island in the chain, might be used as an advance air base for attacks on Hawaii's main islands.

To preclude that, Alymer Robinson, Keith's uncle, began plowing up Niihau. "They started with mules," Keith Robinson says. After the Japanese sinking of the USS *Panay* in China's Yangtze River in 1937, the Robinsons added the tractor power. In all, over 50 of the island's 70 square miles were rendered unusable, all at the family's personal expense. "Alymer Robinson and the Niihauans really stepped up to the plate," says Syd Jones.

From a helicopter today you can still see traces of Niihau's furrows, especially along the island's drier barrens. It was these that denied Shigenori Nishikaichi a safe landing, sending his Zero crashing into brush and boulders that December 7 morning. While Pearl's mighty defenses fell, Niihau's held.

Sightings

PICTURES WORTH A SECOND LOOK

WHEN AIRBUS DECIDED to take its new A380 passenger airplane on a worldwide tour in late March, Washington, D.C., was on the short list of stops.

The European consortium that makes the airplane is trying to drum up business around the globe with what they called a "route-proving flight." With the airplane delivered two years late, any positive press is welcome. Gracing the skies over America's capital with the largest civilian airliner ever made—just before spring, no less—provided a photo opportunity the company couldn't pass up. Local aviation photographers wouldn't miss it either.

On March 26, the National Air and Space Museum's Eric Long took this photo of the Airbus flying over the National Mall from a dual-engine Eurocopter AS350 AStar helicopter owned and piloted by Museum board member Tom Pumpelly.

Long estimates that coordinating the flyover took 500 hours of planning among officials from the Transportation Security Administration, Airbus, and the Federal Aviation Administration.

"[Pumpelly] has donated his time and expense in order for NASM to get this shot and other important shots like it," Long says. It took three weeks for Pumpelly to receive waivers for his helicopter flight.

Hovering 1,500 feet over Virginia, Long and Pumpelly waited for the behemoth to cruise along the Potomac River in a simulated approach to Reagan Washington National Airport, though it actually took off from and landed at nearby Dulles International Airport. The airplane swept over the river serenely at 1,000 feet.

Following at a distance of no closer than 1,800 feet, Long captured the new airplane flying over some of the nation's most famous icons, creating an image that seems natural and unforced, one that belies the planning and coordination that went into making it.

It is one of the few photos that manage to show the entire aircraft during its visit to Washington; photographers who shot from the ground complained the A380 was too big to fit in a single frame.

Barrier Buster

One of the world's most accomplished pilots, Jackie Cochran was a complex, contradictory woman.

NASM (SI NEG. #2006-282/COURTESY FAIRCHILD INDUSTRIES)

NASM (SI NEG. #78-15317)

Jackie Cochran loved makeup, fashionable clothes, and the number 13, which she considered lucky.

Jackie Cochran: Pilot in the Fastest Lane

by Doris L. Rich. University Press of Florida, 2007. 279 pp., $24.95.

"THIS IS JACKIE COCHRAN. Clear the field." With that loud and clear transmission, she once trumped the traffic pattern at a busy air base. It could have been her motto.

In Doris Rich's latest aviation biography, barefoot, illiterate Bessie Pittman reinvents herself as Jacqueline Cochran, the brash beautician who set more speed and altitude records than any pilot in history. Rich meticulously chronicles Cochran's unflinching will, and also the ambiguities of her story: the alpha female who disdains feminine camaraderie, yet flaunts chic fashions and her own name-brand cosmetics; the blustering self-promoter, fading in the fame of her more refined, cerebral contemporary, Amelia Earhart.

But how she flew. She won the Harmon Trophy 14 times as well as 1938's Bendix Trophy. First woman to land on instruments, first on an aircraft carrier. Denied the opportunity to fly a U.S. Air Force jet because of her gender, she borrowed a Canadian F-86 and became the first woman through the sound barrier.

On the ground, her moving and shaking produced mixed results. Galvanized by the war effort, Cochran brainstormed the Women Airforce Service Pilots (WASPs) in 1942. But her abrasiveness and Rolodex of grudges grated against the military-political establishment. Congress declined to give WASPs military status, and the group was disbanded in 1944. Later, Cochran

campaigned to represent her California desert district in the U.S. House and lost.

Too much information bogs a few passages, but many of Rich's revelations are intriguing. An earnest clairvoyant, Cochran experienced telepathic visions of Earhart alive and afloat in her ditched Electra (see "An American Obsession," p. 20). "I followed the course of her drifting for two days," Cochran reported, while searchers scoured the area. When the extra-sensory flashes faded, she lit a candle for the departed soul of her rival and friend.

Nobody ever needed psychic ability to pinpoint audacious Jackie Cochran's whereabouts. But Rich illuminates the lesser-known facets of this under-appreciated pioneer and lights a belated candle for her too.

STEPHEN JOINER IS A FREQUENT CONTRIBUTOR TO *AIR & SPACE/SMITHSONIAN*.

>>> At a Glance <<<

The China Clipper, Pan American Airways and Popular Culture

by Larry Weirather. McFarland, 2007. 335 pp., $35.

The author examines how Pan American Airways' popular flying boats achieved icon status, as reflected in toys, movies, pulp fiction, comic books, and music during the 1930s and '40s.

Red Flag: Air Combat for the 21st Century

by Tyson V. Rininger. Zenith Press, 2006. 128 pp., $19.95.

Photographer Tyson Rininger, a frequent *Air & Space* contributor, presents a behind-the-scenes portrait of the complex fighter pilot training exercise conducted at Nellis Air Force Base in Nevada.

Secret Projects: Flying Saucer Aircraft

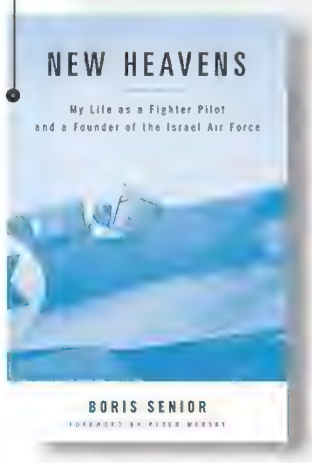
by Bill Rose and Tony Buttler. Specialty Press, 2006. 175 pp., $44.95.

With 245 photographs and more than 200 drawings, *Secret Projects* looks into the development of 20 aircraft that look like flying saucers, including the Vought V-173 Pancake and the Focke Wulf vertical-takeoff-and-landing craft.

New Heavens: My Life as a Fighter Pilot and a Founder of the Israel Air Force

by Boris Senior. Potomac Books, 2007. 256 pp., $16.95.

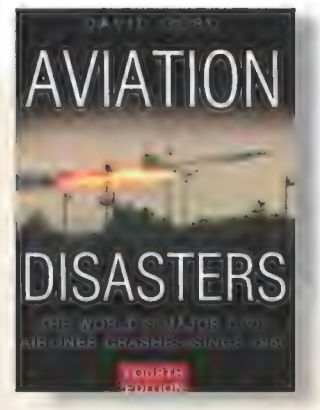
The author details his military flying career, which began with Britain's Royal Air Force and continued with combat experience during Israel's 1948 war.



Luftwaffe Advanced Aircraft Projects to 1945

by Ingolf Meyer. Specialty Press, 2006. 190 pp., $54.95.

Ingolf Meyer displays the imaginative designs of German aeronautical engineers up through the last days of the Third Reich.



Aviation Disasters: The World's Major Civil Airliner Crashes Since 1950, Fourth Edition

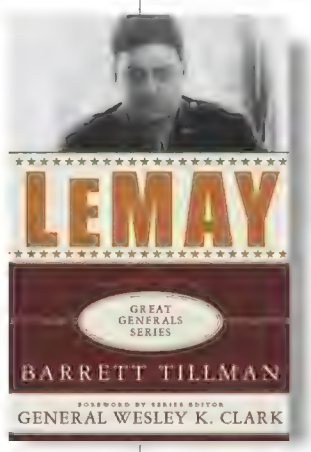
by David Gero. Patrick Stephens Limited, 2006. 368 pp., $44.95.

This book describes hundreds of airliner accidents, starting with the crash of an Avro 689 Tudor V in Wales on March 12, 1950, and ending with an Armenian airliner plunging into the Black Sea on May 3, 2006, killing all 113 passengers and crew on board.

LeMay: A Biography

by Barrett Tillman. Palgrave Macmillan, 2007. 205 pp., $21.95.

LATELY, BIOGRAPHIES have tended to concentrate on their subjects' personalities and environment as much as on their achievements. Not so with *LeMay: A Biography*, written by Barrett Tillman for Palgrave Macmillan's "Great Generals" series. General Curtis E. LeMay was a legendarily stoic man, and the author does not even attempt to crack that veneer.



Rather, Tillman highlights LeMay's aeronautical and martial achievements during World War II and, as head of the Strategic Air Command and chief of staff of the U.S. Air Force, the cold war.

Introduced by a tepid, unenlightening forward by General Wesley Clark, the book is as much a chronicle of LeMay's airplanes as it is of the man himself, from the Consolidated PT-3 biplane trainer he flew in 1927 to the six-engine XB-70 Valkyrie he advocated in 1964. LeMay's name is closely associated with some grand airplanes, including Boeing's B-17 Flying Fortress and B-29 Superfortress and Convair's B-58 Hustler.

As Tillman introduces each airplane, he shows LeMay's hand in driving development or honing tactics. An interested reader will pick up plenty of lore from the early days of these famed airplanes; in this regard, the book is a success.

However, despite its detailed research, the book shows little understanding of the kind of guy he was. In fact, some of the anecdotes celebrating LeMay's micro-managerial style suffer from a lack of personal context.

For example, Tillman marvels at the fact that LeMay was instrumental in bringing the M-16 rifle into existence after he popped off a few rounds from an AR-15 (the M-16's predecessor) at a party. The festivities were held at the home of the president of the company that owned Armalite, which made the rifle and went on to win the M-16 contract.

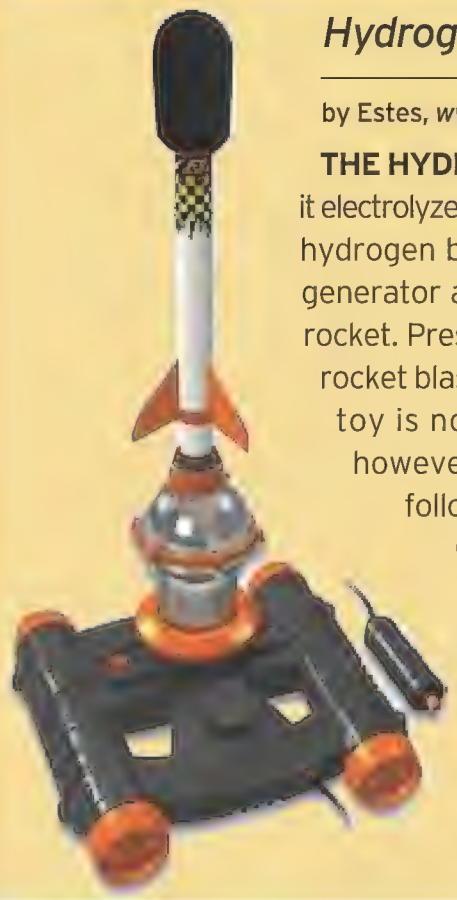
Well, was LeMay in the habit of partying with military contractors? Did he enjoy it or feel obligated to go? Was the AR-15 test shoot at the party a public relations stunt? Was it a favor to a friend, a professional obligation, or a setup? Was it typical behavior for LeMay? The reader has no idea. No family members and few military contemporaries are interviewed, and no personal papers are explored, aside from LeMay's own published works.

If a book is going to rely on the dry recitation of the technical achievements of a military career, it helps to have a subject the size of LeMay. His influence is lasting, under-appreciated, and often maligned by stereotypes.

A biography of a general, especially one as influential and fascinating as LeMay, does not have to be packed with emotion and psychoanalysis. But at some point, the achievements are not enough. The measure of a man has to include an appraisal of his character.

JOE PAPPALARDO IS AN ASSOCIATE EDITOR AT *AIR & SPACE* AND THE AUTHOR OF "ALENIA'S GAMBLE," P. 28

>>> Fun Stuff <<<



Hydrogen Rocket Kit 1876

by Estes, *www.estesrockets.com*, $29.99.

THE HYDROGEN ROCKET'S trick is that it electrolyzes a citric acid solution to produce hydrogen bubbles, which boil up from a generator and collect in the shaft of the rocket. Press the igniter and – *pop!* – the rocket blasts itself to about 60 feet. This toy is not meant for the impatient, however; if the instructions are not followed precisely, it will not work. Only one of my first dozen attempts launched, but after I scoured the directions and mastered the launch protocol, the rocket popped repeatedly until it was time to go home (to find a G.I. Joe figure to strap to it).

Moon in My Room

by Uncle Milton, *www.unclemilton.com*, $27.95.

SURE, THERE IS A LATENT EDUCATIONAL purpose for Moon in My Room: Put in batteries, hang it on the wall, and use a remote control to cycle through 12 lunar phases, from new to full moon. An audio CD provides a short, friendly, and wide-ranging lecture on topics from the Apollo missions to the Seneca tribe's belief in a wolf spirit that sang the moon into existence. Really, though, this is the world's most charming nightlight – I smile every night when I turn it on before bedtime.

SAM GOLDBERG, A FORMER ASSOCIATE EDITOR AT *AIR & SPACE*, DEVELOPS MUSEUM EXHIBITS IN SEATTLE, WASHINGTON.

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>>> Airplanes on Film <<<

Firefox

DVD. Rated PG. Warner Home Video, 2002. $9.99.

ORIGINALLY RELEASED IN 1982, *Firefox* tells the story of the U.S. attempt to steal an advanced Soviet aircraft, the fictional Firefox, before it becomes operational. Speaking in the film of the Mach 5 Firefox, a U.S. intelligence officer says, "If the Soviets can mass-produce it, it will change the structure of our world."

Clint Eastwood, who also directed the film, plays Mitchell Gant, a retired fighter pilot and Vietnam veteran living as a recluse in the Alaskan wilderness. Though Gant is troubled by Vietnam war flashbacks, he is deemed the only pilot experienced enough to carry out the mission, which requires him to sneak into the Soviet Union on a false passport, make his way to a highly secure air base, and, with the help of some dissident engineers there, fly away in an aircraft he has never seen. Piece of cake.

The first half of the film, darkly lit and too long, shows Gant's numerous encounters with KGB agents, one of whom he offs in a men's room after rousing himself from yet another flashback. Viewers who hang in there hoping for a big payoff once Gant finally straps into the Firefox will be disappointed by some of the uncoolest flying scenes ever filmed. Once inside the cockpit, Gant talks constantly to himself, saying things like "Let's see what this thing can do," and, later, "Let's see what this baby can do."

A clever plot turn has Gant refuel the Firefox by landing on a polar ice bank to rendezvous with a U.S. Navy sub that punches through the ice. When Gant gets out of the aircraft for the refueling, he tells one of the sub's crew, "Check the tires and windshield, will you?"

The Firefox is represented by a model, and the special effects that animate it have the feel of a bad videogame. For superior flying scenes, rent 1986's *Top Gun*, which used real aircraft in live-action flight sequences. As for Eastwood fans, they'd be better entertained watching the Hollywood great wield a Smith & Wesson than an aircraft control stick.

AIR & SPACE ASSOCIATE EDITOR DIANE TEDESCHI IS A LONGTIME CLINT EASTWOOD FAN.

Harrier II: Validating V/STOL

by Lon O. Nordeen. Naval Institute Press, 2006. 210 pp., $28.95.

More than any other military air arm, U.S. Marine aviation has staked its future on warplanes that do not require runways. The Marine Corps' current program to acquire 360 Bell-Boeing MV-22 Osprey tilt-rotor assault aircraft is visible and controversial, but the leathernecks' infatuation with vertical/short-takeoff-and-landing (V/STOL) aircraft began with the 1971 delivery of the first AV-8A Harrier.

Harrier II, by longtime Boeing (originally, McDonnell) business development expert Lon O. Nordeen, provides a comprehensive history of the family of American V/STOL aircraft that evolved from Britain's Hawker Siddeley Harrier.

When no one else in the Pentagon cared much about V/STOL—even though some said fixed runways were vulnerable to Soviet attack during the cold war—the Marines pressed for their version of the Harrier. With a heritage of innovation and with leaders like now-retired Lieutenant General Thomas H. Miller, the Marines defied convention by studying Britain's V/STOL experience and, ultimately, improving on it.

Nordeen's volume treats the AV-8A, including its near-cancellation in the 1970s and appalling accident rate in the 1980s, as prelude to the second-generation AV-8B Harrier II. The AV-8B, upgraded over time with radar and night-attack technology, fought in the 1991 Persian Gulf war and in Iraq and Afghanistan. Nordeen provides a wealth of interviews and statistics to demonstrate the value of the AV-8B in all four of the Marines' tactical air missions: air superiority, reconnaissance, interdiction, and close air support.

The wealth of data in its appendices alone makes this volume a valuable addition to the libraries of military aviation fans, but the book never makes good on its subtitle. Though Nordeen argues eloquently for V/STOL, in the end, he fails to convince this reader that the Marines couldn't fly their tactical air mission at lower cost and with equal effectiveness from concrete runways.

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A Story With Five Sides

NASM (SI NEG. #78-19121)

HOOVER FIELD, THE FIRST MAJOR airport serving the nation's capital, was unloved from the start. Built by the Pennsylvania Rapid Transit Company in 1926 in five and a half days so Washingtonians could fly to Philadelphia for that city's 150th anniversary celebration, the airport had a less-than-ideal location on the Virginia banks of the Potomac River.

Prone to flooding, the 38-acre field was constrained by the river, Arlington National Cemetery, a government testing farm, three immense radio towers, and Highway 1. To top things off, the field got the stench from a nearby brickworks and one of Washington's largest garbage dumps. In aviation pioneer Wiley Post's

Much-maligned Hoover Field was paved over in the 1940s to become a national landmark known as **(next page)**

DEPARTMENT OF DEFENSE

...the Pentagon. The field was replaced by Washington National Airport (later renamed Reagan), just a mile away.

opinion, "There were better landing grounds in the wilds of Siberia."

But it was good enough for some airlines, and in 1927 the competing triangular Washington Airport opened just across busy Military Road. From the two fields, Clifford Ball Airlines flew its six-seat Fairchild 71 to Pittsburgh, Seaboard Airlines had a daily eight-seater to New York, and Potomac Flying Service offered sightseeing flights over the U.S. capital.

The Great Depression forced the two fields' owners to sell to National Aviation Corporation, which merged them in 1930 under a new name: Washington-Hoover Airport. Military Road now intersected the combined airport's single 4,200-foot runway. "You were supposed to stop when an airplane landed, but Washington drivers...," says Sara Collins, a retired Arlington County Public Library historian. So the sheriff posted guards at the intersection to raise a chain for each takeoff and landing. The criticism persisted. "To the shame of U.S. commercial aviation, which leads the world in volume, the airport at the U.S. capital is one of the world's most dangerous," huffed *Time* magazine in 1938. "Trickier to get on and off than an old-fashioned boiled shirt, hemmed in by a landscape as disheveled as a congressman's collar."

The airport's owner was moved to upgrade Washington's air terminal. The choices came down to fixing up Washington-Hoover, building inland at Camp Springs, Maryland, or dredging a new site from the mud silts at Gravelly Point, to the southeast. The Gravelly Point plan led to the opening of Washington National Airport in 1941 and Washington-Hoover was closed, freeing its unappealing real estate for other uses.

Where the old airport once stood, the 29-acre Pentagon now squats. With 17.5 miles of corridors and three times the office space of the Empire State Building, it is one of the world's largest office buildings.

Ground was broken on September 11, 1941, and the building, which straddles the old brickworks and garbage dump, was dedicated 16 months later. The Pentagon today provides workspace for about 26,000 military and civilian employees. Motorists using the North parking lot today are driving atop what was once Hoover Field, while those in the South parking lot are on the former Washington Airport.

ROGER MOLA

>>> Credits <<<

How to Build a Test Pilot. Randy "Laz" Gordon's long-term goal is to start an aviation-based mentorship program to help young people achieve a career in aerospace.

Paper Ace. Kevin Saavedra grew up in Los Angeles at a time when Tomcats never flew without a Kenny Loggins soundtrack.

An American Obsession. Paul Hoversten is *Air & Space/ Smithsonian*'s executive editor.

Can We Hear Them Now? Tony Reichhardt is an *Air & Space* senior editor.

Alenia's Gamble. Joe Pappalardo is an *Air & Space* associate editor.

Flight Lines. Mariana Gosnell, author of *Ice: The Nature, the History, and the Uses of an Astonishing Substance*, has never made a contrail (she flies 25,000 feet too low).

Buried at the Bottom of the World. Carl Hoffman is a frequent *Air & Space* contributor.

50 Ways to Space Out. Roger A. Mola is an *Air & Space* researcher.

Restoration: 'Hawks Come Home. Ken Scott spends his time building and flying airplanes in Oregon.

In Thrust We Trust. Peter Garrison wrote about wind tunnels in the Feb./Mar. 2007 issue.

How Things Work: Afterburners. Damond Benningfield is a freelance science and technology writer and radio producer in Austin, Texas.

The Niihau Zero. Aerospace engineer Nick D'Alto grew up on stories of the Pacific air war from his dad, a medic with the Fifth Air Force.

Forecast

ON THE WEB AND IN THE WINGS...

Zeros, Warhawks, and Robots at www.airspacemag.com

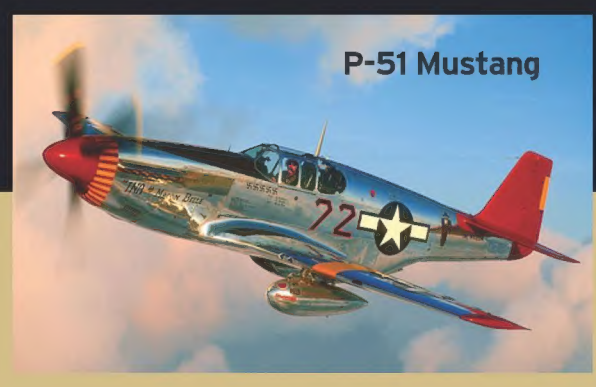
FEATURES IN THIS ISSUE OF *AIR & SPACE/SMITHSONIAN* led us to many more stories about airplanes and airplane builders, which are now available on the magazine's Web site. Readers of "The Niihau Zero" (p. 66), for example, may wonder how many of the Japanese warbirds are still flying. Visit the Web to learn the histories of the last airworthy Zeros.

One of the pair of U.S.-built P-40K Warhawks restored by 28-year-old Erik Hokuf ("Restoration," p. 56) was the Grand Champion warbird at last year's Experimental Aircraft Association gathering in Oshkosh, Wisconsin. For more details of the restoration, see additional photos and an *Air & Space* interview with Hokuf.

The industrial artisans of modern aviation come with gears, hydraulics, and silicon brains. Meet the array of robots inside an Italian airplane manufacturing plant ("Alenia's Gamble," p. 28).

Besides these supplemental features, visitors will find other Web exclusive articles and our usual slate of regularly updated columns, including New Worlds, a blog from planetary scientist Bob Craddock, who takes us on occasional tours of the solar system from his vantage point at the National Air and Space Museum's Center for Earth and Planetary Studies.

And take some time to scroll through the magazine's Reader Scrapbook, a gallery of aerospace photos from every era, submitted by readers.



P-51 Mustang

© PHILIP MAKANNA/GHOSTS

IN THE NEXT ISSUE

Mustangs: The Final Roundup

Read the stories behind seven great fighters that will fly to Ohio this September for the largest gathering of P-51s since the Korean War.

Danger: Airplane Crossing

Collisions on runways are today one of the chief hazards of commercial aviation, according to the National Transportation Safety Board. Will technology now being developed arrive in time to prevent a disaster?

SPACE AGE 50 FIFTY YEARS

<<< Russian Revolution

Sputnik was a stunning triumph for the Soviet Union. Learn what led to the success and what happened inside the nation on the day the first manmade satellite was launched.

Instant Airport, Just Add Party

Once a year, tens of thousands of revelers from around the world gather in Nevada to celebrate a festival called Burning Man. And for a brief, glorious time, the party is served by a makeshift airport that appears in the desert.

Around the World in 175 Days

SHELDON COHEN/BELL HELICOPTER

Jennifer Murray and Colin Bodill exuded confidence the day before their departure in December 2006 .

LAST DECEMBER, TWO FLIERS set out from Forth Worth, Texas, as fast as their fire-engine red Bell 407 helicopter could carry them (which happened to be about 150 mph). They had a schedule to keep. They were attempting to fly around the world via the north and south poles, and they planned to make it back to Texas in under six months.

Hardly anyone noticed when they left to begin what was their second attempt at a flight over the poles. They had tried it once before, in 2003, and crashed. Getting back home and setting a world helicopter record for the route, however, is a sure headline getter.

Jennifer Murray and Colin Bodill don't give up easily. And being British (although Murray was born in the United States), they undoubtedly have the stiff upper lips needed to endure long periods of adversity connected by bouts of boredom. Both have set other records: Murray for speed around the world solo in a helicopter along the usual route crossing all the longitudes, Bodill for doing the same thing in a weight-shift microlight airplane—the kind without conventional control surfaces.

This flight was a series of hops between exotic places like Cuzco and Arequipa, Peru, and Vagar and Hornafjordur, Iceland, sometimes just stopping for fuel (provided by sponsor Shell) or maintenance and occasionally spending a few nights. On the way, they stayed in touch with the outside world and interested schoolchildren via a Web site (*www.polarfirst.com*) to show where they'd be at any moment and what they were thinking and doing.

On their way to both polar ice masses, they touched down in 32 countries and visited a number of schools along the way. They landed at the South Pole on January 7, in Antarctic summer.

Bell Helicopter, a division of Textron, provided its 407 for the project because a flight like this is, in effect, an advertisement for the durability of its aircraft. Helicopters, by virtue of their rotary wings, operate with a high percentage of their parts in motion all the time they're flying. And all that motion means wear and tear, which is why helicopters ordinarily need more maintenance than fixed-wing aircraft. But the payback is the ability to hover, which comes in handy for rescuing people, among other things.

By choosing the polar route, the two adventurers also flew through extremes of heat and cold, further testing the aircraft. Coping with weather extremes was just one challenge: They got stuck in bad conditions in Antarctica. Who knew the elephant seals of Antarctica would attack a human? Bodill does; he had a run-in with one.

So project Polar First makes the statement that the helicopter has grown up a lot since the early days, when the pioneers made flights measured in minutes. The two pilots also communicated at every opportunity their message about connecting the peoples of the planet. A goal of their flight was to encourage concern for our shared environment.

They certainly got a close-up view of Earth from their extremely low orbit of it. And although they've flown together before, both the 66-year-old grandmother and the 55-year-old father of two undoubtedly tested their own good natures (she loves classical music; he loathes it) over the many weeks of their journey.

GEORGE C. LARSON, MEMBER, NAA